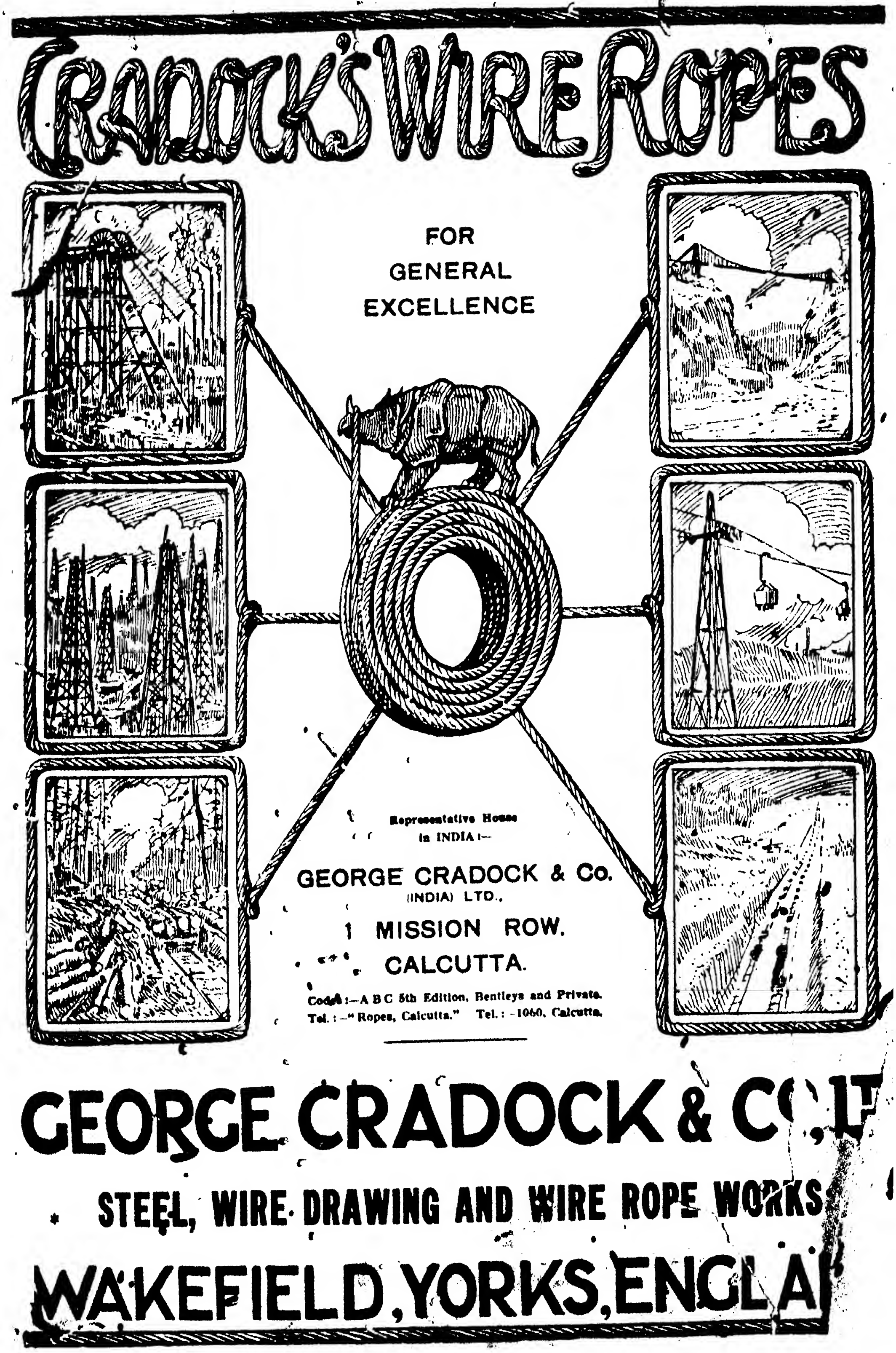
BIRENDRA NATH DEY, ESQ.
B.Sc. (Eng.), A.M.Inst.C.E., etc.

See page 7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INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

Volume II | AUGUST, 1922 | Number 1

BETWEEN OURSELVES

Our First Birthday

WITH the present issue of "INDUSTRIAL INDIA" we commence the first number of our second volume. During the past twelve months we have passed through a period of industrial depression, which is probably unparalleled in international history. From almost every point of view it would appear to have to have been unfortunate and unpropitious to launch out with a new industrial magazine. On the other hand, we realised that during the war, India had laid a wonderful foundation for her future industrial expansion. Combined with this fact we had considered her almost unlimited natural mineral wealth, and we decided to take our courage in both hands and to launch out with an industrial journal, which should have no rival as to the variety and authenticity of contents.

Looking back over the past twelve months we feel that our courage has been in every way justified during the period under review. We have had so many nice things said about us, not only in India, but in almost every part of the civilized globe, that we must have filled the necessary niche. So much has this been so that we should honestly relish a little more criticism, and we take this opportunity of inviting our readers, not only to write us on matter in which they are experiencing difficulties, but we would also ask them to investigate and to consider the general welfare of India's Industries as a whole, and to tell us frankly if they consider we have in any way failed to meet the situation.

Our principal aim in publishing "INDUSTRIAL INDIA" was to keep the country's Industrialists informed on the latest western industrial practise. This was certainly a large order, but there are so many factors which might be termed economic factors, which are common to most industries, that we decided to plan a magazine on general lines, and each month to specialise in greater detail upon some one particular branch of industry, and to take the various branches in turn. We decided on this plan after much thought and discussion, and in view of the fact that India was at the commencement of her industrial career, we thought that this particular plan was the most likely to meet the peculiar situation.

In starting our new volume, we have decided to carry on in the same general way in which we started, and to divide up our contents into sections, as this seems to be the most convenient form for our readers, and the most likely method of meeting their requirements. We have, on the other hand, made minor modifications which we hope will be still more beneficial to the requirements of the magazine.

Our principal aim and object in the future, as in the past, will be to publish in "INDUSTRIAL INDIA" the latest facts regarding the development of, and the most efficient and economic working of every branch of industry in which India is pre-eminently interested. Such development will not only include the material side, but also the human side, and we believe that it is only by co-ordinating in mutual confidence these two sides of industry, that we can work along the most scientific and modern economic lines of conducting our business.

During the coming year we hope to still further justify our existence, and also to prove that we are filling a want which has been felt by the remarkable growth and expansion of the country. From the almost world wide recognition of our first year's working we feel justified in pushing forward our policy and in claiming the support of not only every advertiser interested in the Indian market, but also of every Industrialist whose welfare and interest is concerned with the building up and the exploitation of the vast resources which are undoubtedly contained within what we are pleased to term "The Great Indian Empire."

* * *

An Indian Consulting Engineer's Success

In our June issue we published a brief introductory note outlining the extensive constructional work being carried out at the Provan Gas Works of the Corporation of the City of Glasgow. This work happens to be to the exclusive design and economic system of construction developed by an Indian Consulting Engineer, namely Mr. Birendra Nath Dey B.Sc. (Eng.) A.M.Inst.C.E. etc., Consulting Engineer (Civil, Mechanical and Electrical). It may be said that Mr. Dey is the first Indian Consulting Engineer who has achieved a success of this sort in Great Britain, and his record confirms our contention that the purely Indian Engineer has a chance of achieving the highest position in his profession if he will only give his utmost courage, ability and industry to winning the laurels which await him.

We are in the present issue publishing the first section of a detailed and fully illustrated description of the plan designed by Mr. Dey. In our frontispiece we reproduce Mr. Dey's photograph, and we would like to take this opportunity of congratulating him upon his most important achievement, and what is even more dear to our hearts we would like to record his success as an encouragement, and an incentive to others of his nationality to follow in his footsteps. It is always relatively easy for others to follow where a pioneer has

led, and Mr. Dey's success in securing and carrying through such an important undertaking as the extension of the Glasgow Gas Works is truly an encouraging and inspiring achievement.

Mr. Dey, who was born in Calcutta in 1892, was educated at the Calcutta and Glasgow Universities, and obtained honours degree of B.Sc. in Engineering and a certificate of proficiency in Engineering at the University of Glasgow. He specialized in advanced Engineering courses at the Royal Technical College, Glasgow, and afterwards secured practical training with many eminent engineers.

His career has included such posts as Assistant Engineer to the Glasgow and South Western Railway; sometime Lecturer in Engineering at the Techanical College, West Hartlepool; and was retained as Constructional Expert by a number of leading Westminster firms, and he was Chief Engineer for Messrs. Peter Lind & Co., and also for Messrs. Wear Concrete Shipbuilding Co. Mr. Dey is now a director of the International Engineers Syndicate and Economic Structures Company, and also Technical Expert in Engineering Equipment and Organisation of Industries. It is only natural that he is retained by several Indian clients as Consulting Engineer in London.

In addition to the designing and carrying out of various Engineering works in Great Britain, Mr. Dey has acted as Consulting Engineer for the installation of various works, such as drainage schemes, gas, water, and steam supply, etc., and he has published various papers on Construction Works, and has in the course of preparation an exhaustive treatise in four volumes on "Modern Municipal Engineering Practice."

In conclusion we may state that Mr. Dey's War Services include the design of ferro-concrete ships, barges, pontoons, etc., for various firms, and that he successfully carried out several Admiralty and other Governmental contracts.

* * *

Low Temperature Carbonisation of Coal

The South Wales Institute of Engineers held a Conference on the 20th April, at their headquarters, Park Place, Cardiff, to discuss the important subject of the low temperature carbonisation of coal. There was a good attendance and the President, Mr. David E. Roberts, was in the Chair. The following papers were presented and discussed :—

(1) Opening paper by Dr. C. H. Lander, representing the Government Fuel Research Board.
(2) Paper: "National Importance of Low Temperature Carbonisation," by Mr. David Brownlie, B.Sc. (Lond.), F.C.S., etc.
(3) Paper by Mr. W. Everard Davies, "The Low Temperature Carbonisation of Coal."
(4) Paper by Mr. N. H. Freeman, "System of the British Oil and Fuel Conservation Ltd."
(5) Paper on the "Fusion Patent Low Temperature Retort," by Mr. C. J. Goodwin, A.C.G.I., B.Sc., A.M.Inst.C.E.
(6) Paper by Mr. S. Roy Illingworth, M.Sc. (Lond.), F.I.C., etc.
(7) Paper: "Notes on the Maclaurin Carbonising Process," by Maclaurin Carbonisation Ltd.
(8) Paper: "Some Remarks on Low Temperature Carbonising," by Mr. Harold Nielson.
(9) Paper: "Improved Low Temperature By-Product Recovery Gas-Producer Process," by Messrs. The Power Gas Corporation Ltd.
(10) Paper: "Economic Aspects of Low Temperature Carbonisation," by Mr. John Roberts D.I.C., F.G.S., M.I. Min. E.
(11) Paper: "Low versus High Temperature Carbonisation for Production of Smokeless Fuel," by Mr. E. R. Sutcliffe, A.M.I.Mech.E., and Mr. Edgar C. Evans, B.Sc., F.I.C., etc.

As it has already been arranged for Mr. David Brownlie to write a detailed series of articles in this paper on each of the various processes of low temperature carbonisation, which in addition to the above, include the "Coalite," "Lamplough," "Richards Pringle," and "Tozer" processes, it will not be necessary to elaborate the matter at this stage.

The general opinion is, however, that the problems of low temperature carbonisation are now practically solved, and even the Fuel Research Board appears to be coming to this conclusion. The application of the process to the Indian coalfields would enable India to produce a very large amount of motor spirit, oil, and sulphate of ammonia, in addition, of course, to smokeless fuel.

The proceedings at Cardiff were adjourned until the 23rd of May for a further Conference at Swansea.

* * *

Defects in Steel

A very interesting paper was read before the Manchester Metallurgical Society, on April 11th last, by Dr. T. Swinden, on the subject of defects in steel. These defects can be classified under the general heads of manufacture, casting, and subsequent manipulation, and as the subject is such an enormous one, Dr. Swinden confined himself largely to the question of blow-holes. There are two main theories as to the cause of blowholes, one being that the molten steel retains in solution a certain amount of gas, and the others that the cause is a chemical reaction, between the carbon and the dissolved oxide of iron (FeO), which produces carbon monoxide gas. The question of blowholes is certainly a most complicated one and there is no entirely satisfactory explanation. Dr. Swinden is of the general opinion that both solution of gases and internal chemical reactions may go on to a more or less degree at the same time. Certainly the analysis of the gases present in blowholes does not show much carbon monoxide, an average composition being 50 per cent. hydrogen, much nitrogen, and only a small proportion of carbon monoxide. It is very probable that the traces of silicon and manganese present occlude, or absorb hydrogen, which would explain the presence of this gas in the blowholes. It is well known that if the molten metal is violently agitated by mechanical means the blowholes are much diminished, and although this is not a practical method, it is interesting as shewing the benefit of causing the gases to escape quickly.

* * *

Power Alcohol

We are reminded again by the publication of Mr. C. W. Monier-William's book, "Power Alcohol," of the necessity of finding without delay liquid fuels as an alternative to petroleum. It cannot be too strongly emphasised that the known oil reserves of the world are failing and will not last more than 75 years. The present oil output of the world is about 700,000,000 barrels (40 gallon) per annum, of which the United States contributes about 450,000,000 barrels and Mexico 160,000,000, the production of the whole British Empire being only about 15,000,000 barrels, of which India contributes 8,500,000. In practice the United States control over 80 per cent. of the oil supply of the world, and the British Empire about 5 per cent. There are at the present time three possible alternative sources of liquid fuel, the low temperature carbonisation of coal, the distillation of shale, and power alcohol.

The chief method for the manufacture of alcohol is the fermentation of carbohydrates (cellulose, starches, and sugars), and a great variety of forms of plant life can be used for the purpose, such as rice, maize, cassava

sugar cane, potatoes, barley, mangolds etc. In the case of a tropical country like India it would be possible to grow in rotation say maize, cassava, and sugar cane, and to produce 95 per cent. alcohol at a selling price of say 3s. per gallon, or 6d. per gallon for the raw material only. The process consists in crushing the vegetable product and extracting the starch by washing with water, and then, by fermentation processes similar to brewing, converting it into a dilute solution of alcohol, which is then distilled and further rectified to 95 per cent. alcohol. In India, of course, the climate is very suitable for producing a large yield of vegetable starch per acre, but the trouble is that for every gallon of 95 per cent. alcohol produced, 15 lbs. of coal (or equivalent fuel) are required in the rectification. In Great Britain, with a temperate climate, it would be necessary to make use of potatoes, mangolds, barley, or artichokes, and whilst the yield of starch would not be so great the price of coal would be much less. In Great Britain the consumption of petrol is about 200,000,000 gallons per annum, and to produce the equivalent in 95 per cent. alcohol would require 12,500,000 tons of potatoes, or 25,000,000 tons of mangolds. There is no question, however, that if attention was concentrated on the subject the yield per acre of various plants could be increased considerably, and probably also new and better sources of carbohydrates would be discovered, on the lines for example of the recent experiments in France with a plant (Polynniaedulis) from the Andes. This question of power alcohol is worthy of the most serious consideration in India, and with proper organisation, could be made into a valuable source of revenue in addition to the security obtained.

Different Types of Steam Boilers

A recent paper by Captain H. J. Wellingham, dealing with different types of land boiler, serves to emphasise the great practical advantages of the "Lancashire" (and of course "Cornish") boiler. Indian engineers have found by long experience that this type of boiler is remarkably free from breakdowns and will stand rough usage and the vagaries of unskilled labour, together with bad feed water, to an extent unapproachable by any other boiler. Thus in the Lancashire cotton industry, which is considerably above the average in boiler plant efficiency, over 95 per cent. of the boilers are of the Lancashire type, the average life of which, together with almost complete absence of repairs and breakdowns, must be nearly 20 years. Certainly over 75 per cent. of the coal burnt in Great Britain is consumed in the Lancashire boiler. There have been many attempts made in the last 70 years to improve this type of boiler, especially in connection with increasing the circulation by adding tubes at the back, or through the general body of the boiler, and various types of such economic or dry back boilers are on the market. It is a matter of opinion whether the increased circulation obtained is worth the extra liability to breakdown, caused by the addition of these tubes. For conditions such as is generally found in India, especially for very small steam demands, it would seem to be much better practice to instal a small "Lancashire" or "Cornish" boiler in preference to a dryback boiler, and the same applies to the locomotive type of boiler. The water tube boiler is, of course, essential for large units of say 20,000-60,000 lbs. of water per hour, but in India, as elsewhere, such boilers should only be used for large plants under the best conditions both as regards attention and conditions, especially in the way of good feed water.

Fixed Nitrogen and the Electric Furnace

The question of the production of fixed nitrogen is dealt with in a very interesting and valuable book "The Electric Furnace" by Mr. J. N. Pring, published by Messrs. Longmans Green & Co.

As Sir William Crooks pointed out a considerable time ago, one of the most vital problems of civilisation is the provision of an adequate supply of fixed nitrogen for manuring purposes, and this problem is becoming more and more acute. The chief sources of supply at the present time are the Chilian nitrate fields, the carbonisation of coal, and organic manure, but the fixation of nitrogen from the atmosphere by electrical methods is now rapidly coming to the front. In one process the nitrogen combines direct with the oxygen to give nitric acid, which is then converted into any suitable nitrate. For these nitrogen fixation processes a vast supply of cheap electrical power is necessary, and on this account the method is only applicable to countries that have almost unlimited water power. Consequently in Great Britain, where the total horse power available does not exceed 1,000,000, the process is nothing like so interesting as to a country like India, which has something like 27,000,000 potential water horse power.

Another of the nitrogen fixation processes gives the product in the form of calcium cyanide, and as indicating the enormous developments in this field, the world's production in 1918 of calcium cyanide was no less than 780,000 tons. Even in a small country like Norway, the production in 1916 was 30,000-40,000 tons of nitric acid, 5-10,000 tons of nitrate of ammonia, and 6,000 tons of nitrate of soda. In another process the yield is in the form of sulphate of ammonia, and in 1918 the production of one factory in Germany, the Badische Anilin Company, was 500,000 tons. It seems obvious that the most important source of fixed nitrogen in Great Britain will always be by the carbonisation (at high or low temperatures) of coal, whilst in India this is of less importance than the electrical methods.

Steam Meters and Fuel Economy

At the recent conference in London, of the Institution of Naval Architects, one of the most interesting papers was "The Metering of Steam," by Mr. John L. Hodgson. There is no doubt that one of the most neglected sources of fuel economy in industry at the present time is the proper utilisation of the steam meter. Even in Great Britain it will be no exaggeration to say that 99 per cent. of the factories of the country have no proper equipment of steam meters.

In practically every industry, in India of course as in every other country, there are a certain number of general but distinct uses for which steam is required, such as the main engines, electric lighting plant, pumps for main water supply, steam nozzles of mechanical stokers, and the boiling of liquids, in addition of course to specific uses in certain industries. The proper scientific method of management is to instal steam meters on the main steam pipes for these various uses, so as to be able to arrive at a proper system of costing

(*Continued on page 40*)

INDUSTRIES

Conducted by T. AVERY, C.I.E.

THIS SECTION DEALS WITH THE GREAT BASIC INDUSTRIES OF INDIA. IN THE PRESENT ISSUE WE DEAL PARTICULARLY WITH THE INDIGO INDUSTRY

Indigo Research (II)

THE MANUFACTURE OF INDIGO FROM THE JAVA PLANT

This is the second part of Professor H. E. Armstrong's paper dealing with the work carried out with Natural Indigo Research, and which aims at placing the Indigo Industry on a more scientific basis.

IN 1919 I dealt mainly with the agricultural problem, particularly the phosphatic depletion of soils; nothing was said of the process of manufacture. Systematic work has been carried on since 1917 at Pusa to elucidate this process, by Mr. Davis, in collaboration with the Imperial Agricultural Bacteriologist, Mr. C. M. Hutchinson, and considerable progress has been made, especially during the past season or two. In spite of much work by previous observers practically nothing was known of the exact course of the process of extraction.

The dyestuff is not an immediate natural product. Its precursor in the leaf is the simpler substance, *Indoxyl*, C_8H_7ON, which is present in combination with the sugar, glucose $C_6H_{12}O_6$, as the glucoside $C_{14}H_{17}O_6N$ C_8H_6ON $C_6H_{12}O_6$ Indican, which is easily soluble.

To produce indigo, it is necessary that the indican should be extracted from the leaf, that it should then undergo hydrolysis:—

$C_{14}H_{17}O_6N + OH_2 = C_8H_7ON + C_6H_{12}O_6$

and that the indoxyl then obtained should be converted into indigo by oxidation.

$2C_8H_7ON + O_2 = C_{16}H_{10}O_2N_2 + 2OH_2$

The plant is cut at daylight and carried quickly in carts to the factory, where it is packed in large cement-lined tanks; when the charging is complete and weighted boards have been placed on the charge, water is run in, then, after several hours steeping, the extract is run off into beating tanks, where the liquid is brought into contact with air, and the indigo precipitated. As much of the liquid as possible having been run off, the sludge is removed to filters and then to presses, finally the press cakes are dried in the air.

Mr. Davis has discussed his earlier observations on the extraction process at length in Indigo Publication No. 9, published a year ago.

The Main Problems

Two main problems to be solved are: first comes the nature of the process by which the leaf is rendered permeable so that water can enter and the indican pass out into solution; and second, the process by which the hydrolysis is effected. A natural leaf is impervious. At the outset, a more or less vigorous bacterial fermentation is set up in the tank, doubtless at the expense of sugary materials exuded from the cut ends of the plant stalk and bruised leaves. The water used in Bihar is usually hard and alkaline. During the first three or four hours, little if any indican is extracted; then, as the solution become acid, and acidity increases, more and more passes out and is usually hydrolysed forthwith. At Bihar the best results are obtained by stopping the steeping process after about 12 hours; if continued beyond the optimum period, destructive changes rapidly set in, which involve both a loss of indigo and an increase of impurities in the product.

It would not have been a surprise had it been found out that organic acids were formed by fermentative action during the earlier period. This is proved not to be the case; the development and increase of acidity is mainly due to carbonic acid. As this acid by itself acts but slowly upon leaves, although it ultimately renders them permeable, it is probable that the change at the surface is due rather to a combination of c cumstances leading to the death of t leaf and the onset of internal chan which lead to complete degredati of the vital mechanism. Not only carbonic acid formed but oxyg disappears from the solution; a the leaves are in the dark and i mersed in water all unnatural co ditions. Nevertheless, weak as it it is clear that carbonic acid plays extraordinary part in the proc generally, the quality of indigo p duced being the worse the m freely carbonic acid is formed.

Previous workers have inclin to the belief that the indican is co verted into indoxyl and glucose the agency of an enzyme present the leaf. Messrs. Davis and Hutchi son, however, have brought forwa a body of evidence from which it clear that organisms play a p ponderating part. Mr. Davis is ev of opinion that the enzymic acti within the leaf is rather to avoided, as they lead to undesiral results. When the extraction pr cess is set going at the beginning of season, usually the results are po at first, the product being low quantity and quality. The followi data from records secured in 1916 a typical:

	Sumatra Plant. Produce per Sr.	ch.	Java Plan 100 maund Sr.
1st day ...	0	5	7.4
2nd	1	2	10.1
3rd	7	1	6.0
4th	8	0	14.8
5th	Java plant.		12.8
6th	–	–	14.0
7th	11	0	16.0
8th	9	8	14.0
9th	12	2	Steadily at to 16 seer
	Then steadily improving to 14 to 16.		

Apparently during the earlier period the useful organisms are accumulating on the walls and cross beams of the steeping tanks. Mr. Hutchinson has developed a method of cultivating the organisms which occur in the vats on plates of agar containing indican organisms, which liberate indoxyl and are easily distinguished by the blue colour of their colonies. Using this test, Mr. Davis has found extraordinary differences in the way in which the different organisms affect indican, both as regards the rate at which they determine its hydrolysis and the extent to which they have a destructive action on indican.

An interesting opportunity was afforded him in 1919, at a small factory at Panchnoi in Assam, where the manufacture was undertaken for the first time in Assam by Mr. Leo West. During the first month following the Bihar practice, the results were most irregular and unsatisfactory; only from 3 to 13 seers per maund were obtained of an indigo of low quality, containing only from 31 to 53 per cent. of indigotin. The water used was found to be entirely different from that in Bihar, being very soft. When bacterial cultures were made by Mr. Hutchinson's indican-agar method the water as a rule was proved to be extraordinarily deficient in indican splitting organisms.

Some Tests

Mr. Davis further found that when the Panchnoi water was added to a sterilised solution of indican, the production of blue indigo set in only after 36-40 hours, whereas when ordinary Bihar water—well supplied with the indican-splitting organisms—was used, a blue deposit of indigo set in within 12 hours. At Panchnoi, on the 23rd to the 29th extractions, during a period when the results were most variable, it was found that on satisfactory days there was a good development of the indican-splitting organisms, though not on the other days. The water was obtained from a small river rising in the hills a few miles away, and evidently changed its bacterial character very rapidly as the rainfall in the hills varied. At the 33rd extraction it occurred to Mr. West to double its duration. A very high yield and greatly improved quality of indigo was the result and was continued regularly over thirty days in succession. In Bihar, if extraction be continued beyond 24 hours, a very poor produce is obtained. The following example of a steeping vat will illustrate this.

Fermentation time of steeping hrs	8	11	13
Percentage of total indigotin of leaf found in extract	45.4	83.0	56.6
Purity of crude indigo	71.8	66.6	51.8

It will be seen that a loss of nearly two-thirds of the indigotin was incurred by 2 hours over steeping.

Time of Steeping

Mr. Davis was led by these observations to realise that it would be of great advantage to ascertain the optimum time of steeping for the particular conditions prevailing in a factory, and ultimately to devise a simple time test. This involves nothing more than taking every half-hour a sample from the running off pins or by means of a syphon from the bottom of the vat. Five cubic-centimetres of the sample are put into a flask, 6 to 8 drops of strong ammonia diluted with 5 volumes of water are then added, the liquid is made up to 250 c.c. and well shaken, then poured into a 100 c.c. Nessler cylinder. The successive samples are ranged in order, and the depths of colour observed. So long as the extraction is incomplete, the depth of blue colour steadily increases; directly the blue colour begins to appear fainter, extraction should be stopped.

Using this test in Bihar, it is found that every half-hour counts, marked improvements in quality and constancy of products have been effected wherever the test has been introduced. It constitutes a great advance in the technique of the extraction process. Moreover, other improvements are likely to come in its train, as Mr. Davis has found by its use that not only does the extract effected at different heights in the vat vary in strength, but that the closeness with which the charge is packed is of consequence, as the proportion of potential indigotin dissolved out depends upon the ratio of water to plant.

To return to the problem of bacterial action, whilst it is clear that organisms play a determined part, it is not so clear what part of the leaf enzymes take in the process. Unfortunately, the Panchnoi experiments were not carried to the point of ascertaining to what extent the indican was dissolved out of the leaf after different periods of steeping, nor to what extent it had been hydrolysed; the unsatisfactory results may have been due to a preponderance of organisms having a destructive influence upon either indican or indoxyl. No proof has been given, however, that indican as such escapes to any extent from the leaf; the conclusion Mr. Davis draws from his results is merely that the indican is hydrolysed to indoxyl practically as fast as it is extracted from the leaf. Maybe the differences observed are all but entirely the outcome of competitive actions by the different organisms; until these are isolated and their individual effect established, it will be difficult to overlook the entire process.

Indoxyl is one of the most sensitive substances known to chemists. It may exist in solution in two interconvertible forms, in proportions which vary probably with temperature and the effective alkalinity or acidity of the liquid. These may be differently affected by organisms and on oxidation. The results obtained in the beating vat vary as the acidity is varied, and the most favourable results are obtained when the solution is neutral or faintly alkaline with ammonia. The main change in indoxyl is more fundamental, apparently derivatives of this compound are present in the liquor which are not convertible into indigo, but into indigo brown, the nature of which is at present unknown; a considerable proportion of the indican, however, is carried beyond this stage and for this we cannot account at present.

Carbonic acid may have an influence either by retarding or promoting the action of this or that organism; perhaps its main deleterious action is the solvent action it exercises upon proteinaceous substances present in the leaf, which are subsequently precipitated, during the beating process, together with indigo, thus reducing its purity. The so-called indigo-gluten soluble in dilute acids which may form 20 per cent. or more of the crude indigo is formed in this way.

In fine, the process is one of extraordinary complexity and a vast amount of labour, combined with the highest technical skill and acumen will be required to unravel its mysteries, and disentangle conflicting elements.

Special Value of Leguminous Crops

Let me here dwell upon the extraordinary value of an experimental inquiry such as Mr. Davis has initiated into the requirement of a typical

leguminous plant such as indigo. Years ago, Sir William Crookes aroused public interest by drawing special attention to the need of nitrogenous fertilisers if the world were to be kept supplied with wheat. Consequently, the advent of the method developed with such success in Germany of late years of making ammonia from atmospheric nitrogen and hydrogen liberated from water has been hailed with acclamation; yet it is a method involving much capital outlay and a considerable expenditure of fuel; even where water power is available the capital outlay is great. Nature's method of attracting nitrogen from the atmosphere has yet to be appreciated; at least in the East this method alone should be followed; the continual use of costly artificial nitrogenous manures is the outcome of the thoughtlessness and lack of observational and reasoning powers of which we have too long been guilty. We in this country make far too little use of leguminous crops the intervals in which they figure in the rotation are far too long, but it will be said this is because they cannot be grown more often Perhaps indigo can here teach a lesson.

Grass *v.* Wheat

The majority of our pastures are of the poorest quality as fatting lands and miserably starved of leguminous plants. We have to bear in mind that clover is as meat, whilst the grasses are but as bread; man cannot prosper—he can barely exist on bread alone, neither can animals on its equivalent grass. We know what to do to make our pastures be both bread and meat. On the noted sheep fatting pastures of Romney Marsh, the herbage is a luscious mixture of the youngest grass with clover, of clover grown with a cover crop of grass. It has occurred to no one as yet to question whether the clover grown under such conditions has not a special nutritive value as compared with plant grown alone. Not only is the clover grown together with grass but both are constantly fed from above, from the animal droppings, with nitrogen which is a special tonic to the grass, with organic matter and with phosphate, both of which we may suppose especially stimulate the growth of the clover. The grass versus wheat controversy has greatly exercised the public mind of late years, the more because there is an undercurrent of feeling that our grass lands are often inferior, and as it were, meatless lands; yet the farmer has an instinctive love for them; an instinctive belief in their value. Everything is tending now to show the importance of quality as distinct from quantity in food. We in this country greatly need to improve the quality of our food, especially of our milk and butter maybe of our beef and mutton, but as yet we only know that most of it is superior to that we get from abroad, and that we should do well to raise far more of it at home. Our pigs, we do know, have in large part been imperfectly fed, and that pig meat is much improved in nutritive value by grass feeding.

Need of Scientific Aid

Winter grass is poor feed for milch cows, and of the roots the mangold is seemingly worthless in comparison with the swede—the milk made from it being deficient in nutritive power, and yet we grow and use the former far more than the latter. Of late years the seedsmen have vied in producing giant varieties of roots, just as the horticulturists have sought for size in vegetables. Visitors to the Royal Horticultural Society's shows are familiar with the wonderful display of vegetables by Sir Vicary Gibbs in particular. But the onion has lost its savour, the turnip is all but tasteless, the not too broad broad bean has no breadth at all of taste, the tomato is flavourless, etc., etc. Such is the outcome of selection and intensive culture. It is the case of Indigo grown on seet apparently—quantity without quality. We need to pay heed to the lessons Mr. Davis has begun—only begun—to draw from his enlightened studies of one poor leguminous plant and begin over again with our crops. All is not gold that glitters; we have been thoughtless and so academic in our science that workers are in no way sufficiently alive to the great practical lessons, the great practical issues before their eyes, too much of the research we are engaging in is vanity and vexation, in large part trivial and with no practical motive behind it. The difference in value of vegetable products are astounding—the lemon, for example, is a most active antiscorbutic, whilst its cousin, the lime, is worthless. These matters are of the greatest consequence to us all now that we are beginning to be assured that for our growth, our health, our susceptibility to disease we are dependent on certain minor and indeed minute constituents of our food—that food is primarily of value by reason of its quality; and proportion counts. We need many things, but we must have them in due proportion; so must the plant.

It were time that we made more use of our knowledge. Man lives not by phosphate alone, nor does the plant, and yet phosphorus is the nuclear element of all living matter and our primary need; sooner or later the nations must fight over its possession. That India is in sore need of phosphates is clear; yet religion and commerce combine to withdraw it from use—that bones should be so largely exported from the country as they are is striking evidence of the alarming ignorance that prevails on all matters of this kind. Our own position is almost equally bad. To make our meatless grass into good sandwich material we need, in the first place, to anoint it liberally with phosphate then the clover will begin to flourish. Basic slag we know is a good material for the purpose, and yet we are now spoiling this for agricultural use by an altered treatment in the steel furnace; all the other sources of phosphates are foreign. The problem is of infinite importance. The phosphatic stone Mr. Davis has set rolling in India may roll down even upon ourselves, is already upon us, in fact.

However little moss it may gather, it should force us to think and perhaps to realise the moral burden upon us to make more provident use of the fertilising materials at our door, of which there is so small and limited a store at man's disposal.

My object is to make clear the immensity and importance of the problems before us in agriculture, especially in connection with leguminous crops. In view of their magnitude it is the most serious reflection possible upon our intelligence that an industry peculiar to the East and particularly to India, undoubtedly in principle, the root industry of its agriculture, of a lineage than which none is more ancient should have won no proper recognition and support. Mr. Montagu, in his recent speech in the House of Commons, spoke of the industrial and agricultural resources of India as the one cure for the present situation. The special correspondent of the *Times*, a few days later, discussing the impressions of a four months stay, drew urgent attention to India's industrial needs. Agriculture is the chief industry of the country—yet it is to be deprived of scientific aid when it is in sorest need of help.

Installation of Extensive Gas Works Plant

for the Corporation of the City of Glasgow

By BIRENDRA NATH DEY, B.Sc., A.M.Inst.C.E. etc. Consulting Engineer, 94-96 Kensington High Street, London, W.8.
(Director, International Engineers' Syndicate, and Economic Structures Co.)

[The Corporation of the City of Glasgow, in January 1921, invited Mr. B. N. Dey (the only Indian Consulting Engineer practising outside India), along with other Engineers and Engineering Firms, to submit a complete scheme for the installation of large works at Provan (Glasgow) —estimated at £300,000 —comprising reinforced concrete and steel structures, elaborate drainage and foundations, railways, extensive pipe lines and mains for water, steam and gas supply, mechanical plant, conveyors, valves, etc. Mr. Dey's economical scheme was eventually accepted by the Corporation in March 1921, and he was asked to instruct several large firms of contractors in Glasgow, London, and other centres to submit competitive tenders based on Mr. Dey's scheme and designs. The successful contractors, Messrs. McBride and Gray Ltd., 156 St. Vincent Street, Glasgow, are carrying out the works under the supervision of Mr. Dey's Resident Engineer at Glasgow, and to the designs, drawings, specifications, bills of quantities, and detailed instructions from Mr. Dey's London Office.—EDITOR, "Industrial India."]

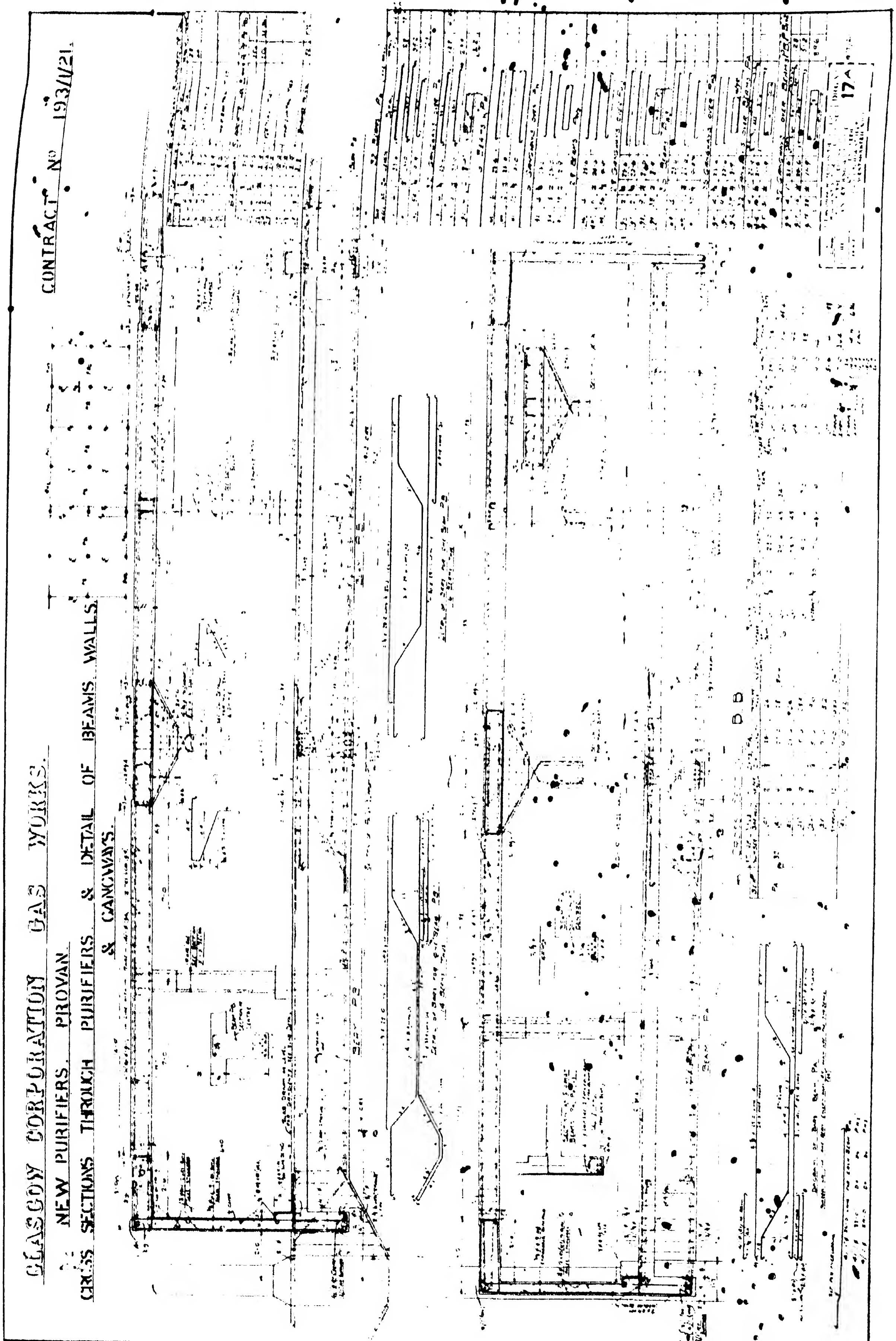
Part I. Reinforced Concrete Structures

THE adoption of reinforced concrete in the construction of industrial plants is now almost universal. This material received a great impetus from the demands created during the war, when steel for structural use was unobtainable except for war requirements. Its increasing application in buildings, bridges, bunkers, tanks, foundations, and industrial structures, was extended to absolutely water and oil-tight structures (as in concrete ships, dock gates, etc.), and to gas-tight tanks known as purifiers in Gasworks. Long after its invasion into those parts of gasworks, common to all industrial plants, its importance and usefulness as a strong, durable and economical material for the construction of gas-tight purifier tanks were recognised by the gas engineers, who were convinced by the successful erection of a number of reinforced concrete purifiers in the special design and system evolved by the author, also by the facts that these tanks could be built at a far lower cost than those in cast iron, and would require no upkeep, not being affected by the gases and vapours, in a gasworks, having corrosive action on iron and steel.

The Corporation of the City of Glasgow have, in course of completion at Provan Gasworks, what will be one of the largest and most modern purifier installation in this country. In preparing plans, schemes and designs for this extensive plant, the author provided as far as possible for the use of concrete in various forms, both plain and reinforced, in his Economic System of Construction, evolved after careful study and as the result of progressive development based on considerable practical experience. The concrete works comprise: foundations and bases for valves and machinery; floors at different levels carrying railways; retaining walls; overhead tanks; buildings; piers and girders supporting standard gauge railways; platforms and gangways; and various structures supporting large diameter pipes, runways for lifting gear, conveyors, stairs, roofs, etc.

The plant is to be used for purifying large volumes of gas. The gas as manufactured from coal by heating it in closed retorts, is full of impurities, of which tarry vapour, ammonia, etc., are removed by cooling and washing, and the remaining impurity, sulphuretted hydrogen, is eradicated by passing the gas through layers of hydrated ferric oxide (found in natural state as "bog ore") placed in large tanks or purifier boxes, each having four steel covers with rubber lutes and fixings. The boxes are carried on columns and beams at a height of about 13ft. above ground level. Periodically, the spent oxide is removed from the boxes, by discharging through the holes in the floor of the boxes into bogies run on rails below the purifiers. Fresh or revived oxide is to be supplied from the revivifying floor about 9 ft. above the boxes, through discharge chutes or conveyors. The oxide is to be brought and distributed over the revivifying floor by a 2 ft. 6 inch. gauge railway from the Oxide store at the west end, which in turn is replenished from the 4 ft. 8½ inch gauge rail tracks, at a higher level delivering both fresh and spent oxide, through disintegrators, into the narrow gauge bogies underneath. The mains supplying the gas to the plant are 48 ins. diameter, reducing to 30 ins. at the west end. The connections from the mains to the purifiers are 24 ins. diameter and 18 ins. diameter pipes, through various valves. The oxide is placed on wooden grids resting on steel bearers supported on concrete ledges, and brackets inside the boxes. The steel covers are lifted when required by lifting gear running on runway joists fixed to beams under the revivifying floor.

The area of ground within which the new plant is being erected is about 702 feet from west to east, and about 240 feet from north to south, amounting to about 19,000 square yards. The new plant is laid out to deal with 24 million cubic feet of gas per day, comprising 24 purifier boxes with six


GLASGOW CORPORATION GAS WORKS.
NEW PURIFIERS. PROVAN.
CROSS SECTIONS THROUGH PURIFIERS & DETAIL OF BEAMS WALLS & GANGWAYS.
CONTRACT No 193/1/21.
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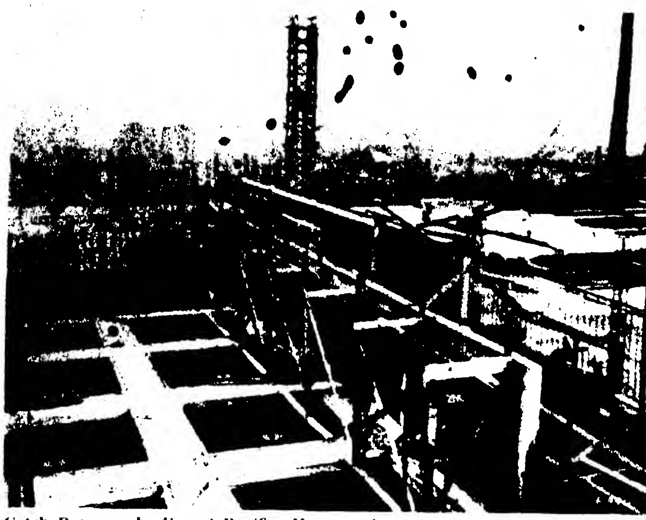


Catch Boxes and adjacent Purifier House under construction

catch boxes (erected between the existing plant and the new purifier plant, which will be used in case of any possible failure of the routine sets of either plant to do the work of purification. The building containing the purifier boxes, when completed, will be 505 feet long from face of No. 2 retaining wall. A revivifying floor is constructed within this building at a height of about 32 ft. from the ground. At the same level on the high ground between Nos. 1 and 2 retaining walls, the new oxide store, about 150 ft. wide, is laid out. Stairs with access to different levels are provided at different points in the plant. Approximately 80,000 square feet of roof area are covered by corrugated asbestos sheeting, with ventilators and gutters for adequate roof drainage, etc. The roofs are carried by steel roof trusses supported by reinforced concrete eaves and valley beams and columns.

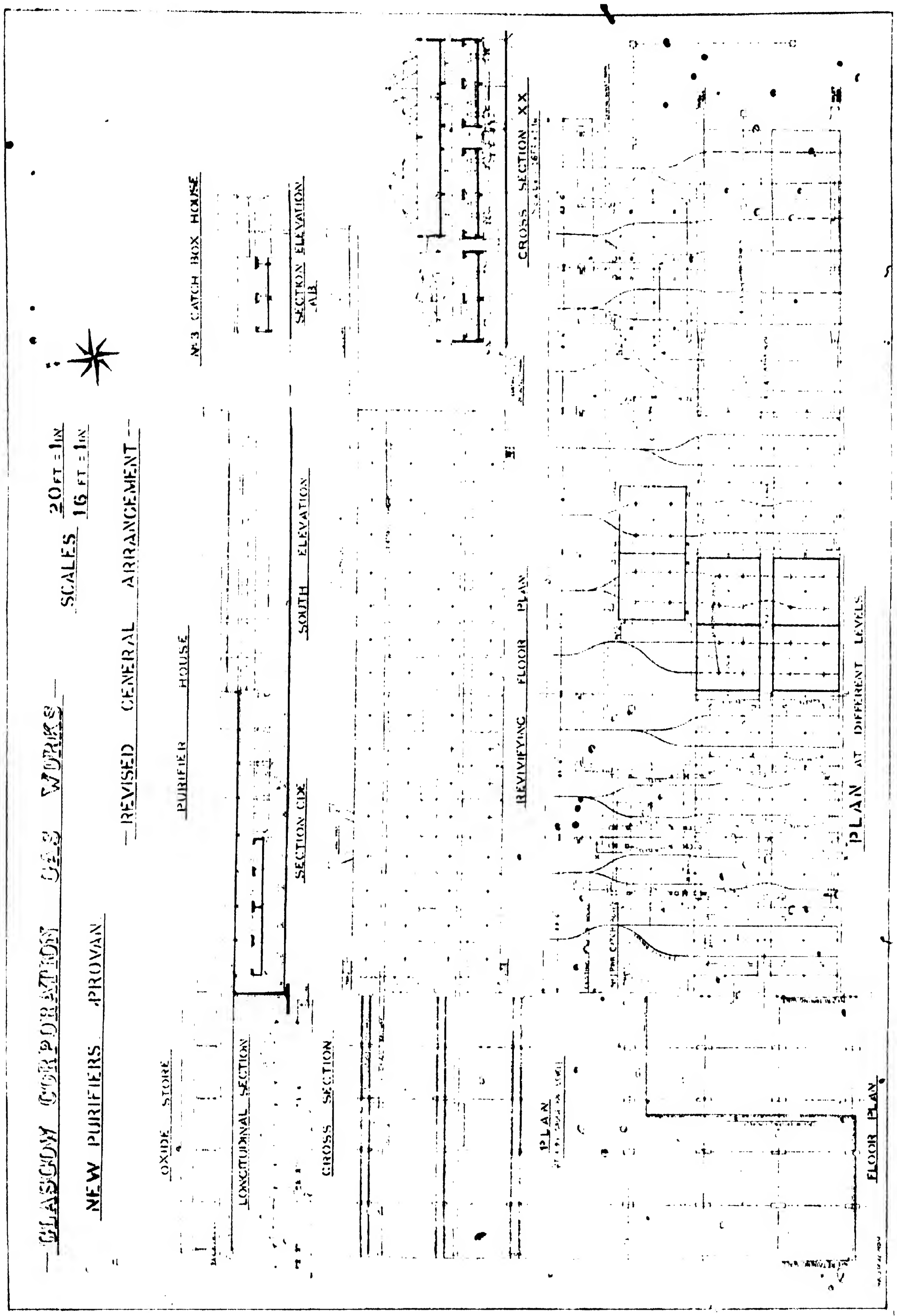
Design. No other system of construction requires so much advanced and thorough knowledge of the theory of structures and of the properties and strength of materials used, as concrete ideally reinforced with steel. Although limitations in stresses of concrete and steel were imposed, the author was allowed to use his own methods as embodied in his economic system, in the preparation of his designs, and instructions for the contractors. These methods, being the outcome of independent investigations, on reinforced concrete treated as a composite material, having special properties which should be utilised to the best advantage, are necessarily at variance with many established ideas based on designing always in analogy with similar steel structures.

Practical considerations also governed the design. The scantlings of the different members of the structures were determined by economical practice, enabling removable units of shuttering to be used repeatedly. The reinforcements were arranged in a simple manner, so that same could be easily placed and inspected.

One of the main features of the design is the comparatively thick slab with few ribs, which has proved to be economical, simple and easy for erection, amply strong to withstand all stresses, and more effectively waterproof and gastight than thin slabs with numerous ribs. Past experience has also proved that oil and gas-tight tanks should first be properly designed with sufficient reinforcement (meshwork on both faces as far as possible), to resist every stress likely to be encountered, and then that the concrete be properly proportioned (a mixture of say cement 1 ; sand 1½ ; aggregate 3), mixed and placed and adequately protected during early hardening so as to develop the proper strength and density ; unless these two essentials are taken care of, no coating on the inside will compensate for them.

Purifiers and Catch Boxes. These boxes are grouped in pairs. The unit pair consists of two boxes with a partition wall between them, each box having inside measurement of about 1550 square feet area and at least 6 ft. depth. The floor slab is average 8 ins. thick, divided into panels about 20 ft. square, which are bounded on two sides by beams 12 in by 30 ins. deep (overall), and the wall beam on the other two sides, carried on columns one at each corner of the floor slab, as shown in drawings. The wall slab, forming sides of the boxes, is 6 ins. thick, and is reinforced to resist lateral pressure due to both pneumatic and water tests. It is also designed to act with the bottom beam portion (9 in. by 30 in. deep) forming wall beam to support one side of the floor slab. The junctions of the wall slab with floor slab at the bottom and gangway slab at the top, are adequately reinforced to resist end fixing moments. The roof of each box is formed by 12 in. thick gangway slabs, leaving four square openings, each about 15 ft. by 14 ft., covered

Set of Purifier Boxes


GLASGOW CORPORATION GAS WORKS
NEW PURIFIERS. PROVAN
SCALES 20 FT = 1 IN
16 FT = 1 IN
REVISED GENERAL ARRANGEMENT
PURIFIER HOUSE
OXIDE STORE
LONGITUDINAL SECTION
CROSS SECTION
SOUTH ELEVATION
No 3 CATCH BOX HOUSE
SECTION ELEVATION AB
CROSS SECTION XX
REVIVIFYING FLOOR PLAN
PLAN AT DIFFERENT LEVELS
PLAN
FLOOR PLAN

by steel covers. The side gangways are 3 ft. wide. The two centre gangways at right angles to each other are 5 ft. wide, and are tied to the floor slab and supported by a central and four other pillars.

The floor and side (wall) slabs are designed to sustain the hydraulic test of filling each box brimming full of water, and to withstand all stresses due to 4 ft. deep of oxide (65 lbs. square feet), evenly distributed and localised loads due to inlet and outlet pipes and oxide discharge valves. The floor, sides and roof (gangways and covers) are also designed to sustain the pneumatic test of 50 inches water gauge pressure applied for six hours. The gangways are designed also to carry an external super-load of 56 lbs. square feet, direct and transmitted through the covers, over and above the weight of the covers. The inside pillars are designed to carry loads transmitted by grid bearers (supporting grids carrying oxide) and to withstand all stresses due to pneumatic test of 50 inches water gauge pressure. The beams are designed to carry the distributed load transmitted by the floor slab, and to withstand all stresses due to localised loads from the pillars, inside the box, and from gas pipes carried on slings supported from the beams, below the floor slab. The beams are designed not to deflect more than one thousandth part of their span under maximum loading.

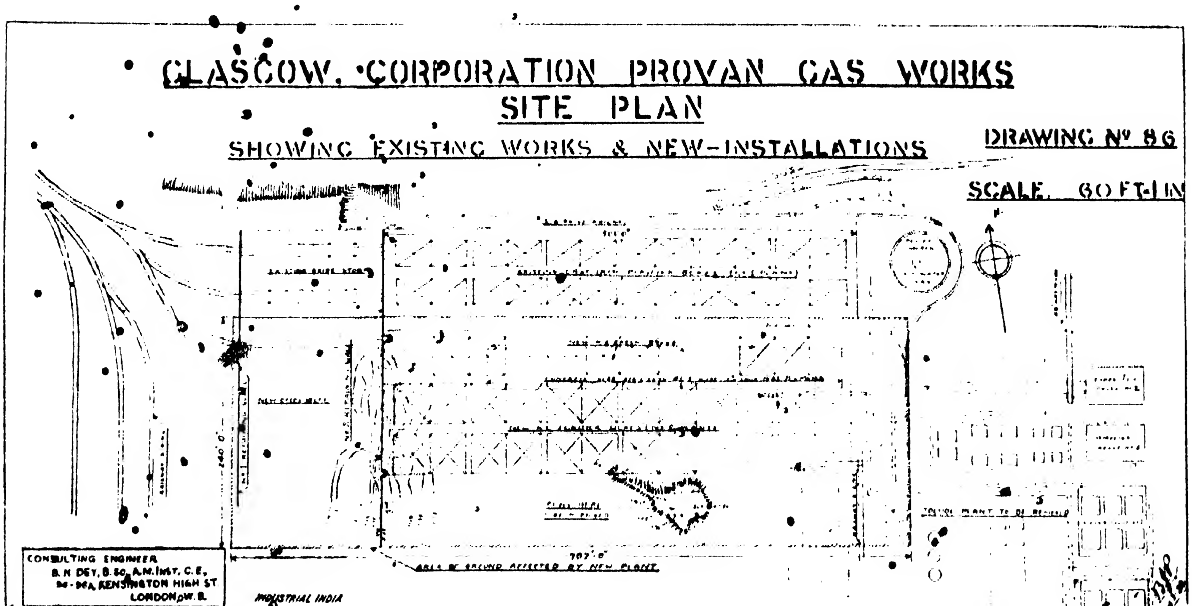
The floor in each box is laid to fall to four drainage holes, and is also provided with eight other holes 18 in. diameter, four for emptying oxide, two for inlet and two for outlet gas pipes. Ferro-concrete ledges and brackets are provided along side walls, to carry grid bearers. The gangway is built with lugs in proper positions, for covers and fixtures, to carry steam coil. The floor sides and gangways are reinforced with steel bars in two directions at right angles to each other. The concrete mixture for the boxes (floor, sides, gangways, beams) is 1 : 1½ : 3, and for columns is 1 : 1 : 2, representing the proportions of cement : sand : aggregate.

Revivifying Floor. This floor over the whole area of the purifier house, above the purifier boxes, is designed to carry a load of oxide 4 ft. deep, or 260 lbs. per square foot. The floor slab is average 8 in thick, divided into panels approximately 19 ft. by 20 ft. and 20 ft. by 21 ft., bounded on each side by a beam 12 ins. by 25 in. deep (overall.) The floor is finished smooth on the face by ¾ in. granolithic incorporated into the slab. One hole in the centre of each panel is provided for distributing oxide to the purifier below. Drainage holes and holes for hydrants and sinks (water supply) are also provided. The floor is graded to surface drains. Each panel is designed for maximum bending moments at centre and at supports, due to most severe cases of loading, viz., maximum for centre when alternate panels are loaded, maximum over support when adjacent panels are loaded. The floor slab is reinforced with steel bars in two directions at right angles to each other, both top and bottom. The reinforcements at the top face are provided to take up tension due to loading of an adjacent panel, and part compression due to centre bending moment when the panel itself is loaded.

The retaining wall around the revivifying floor is 6 in. thick and 6 ft. 6 in. high, and is designed to retain oxide heaped against it up to 6 ft. deep. It is also designed to act with the bottom beam portion (9 in. by 25 in. deep), forming wall beam to support the end floor panels. The junction of this retaining wall with floor slab is adequately reinforced to resist end fixing moment. The reinforcements provided in the wall are steel bars in two directions, at right angles to each other, and on both faces. Openings are provided in this wall for conveyors and staircase landings, where they occur.

The beams are designed to carry the distributed load transmitted by floor slabs, loading due to 2 ft. 6in. gauge railway laid on the floor, and that due to runways supported from the beams under the floor, carrying lifting gear with raised covers. The concrete mixture for the floor slab, beams, and retaining wall, is 1 : 2 : 4, and for the columns supporting the floor is 1 : 1 : 2, representing the proportions of cement sand, aggregate.

Oxide Store. The railway track girders are designed to carry a working load of 2 tons per lineal foot, and are supported on mass concrete piers, the end supports being the



Part View of underside of Purifier Boxes, showing Spacing of Beams and the large Panels of Slabs

No. 1 retaining wall at one end, and two reinforced concrete columns, transmitting the load through a girder to No. 2 retaining wall, at the other end. Over each support is provided a cantilever designed to carry columns supporting the roof. A gangway 3 ft. wide is provided along each track girder, and is designed to carry a superload of 56 lbs. per square foot. Two platform slabs, each 12 ft. by 24 ft., carry the disintegrator machinery and motor house, and are supported by reinforced concrete beams and columns.

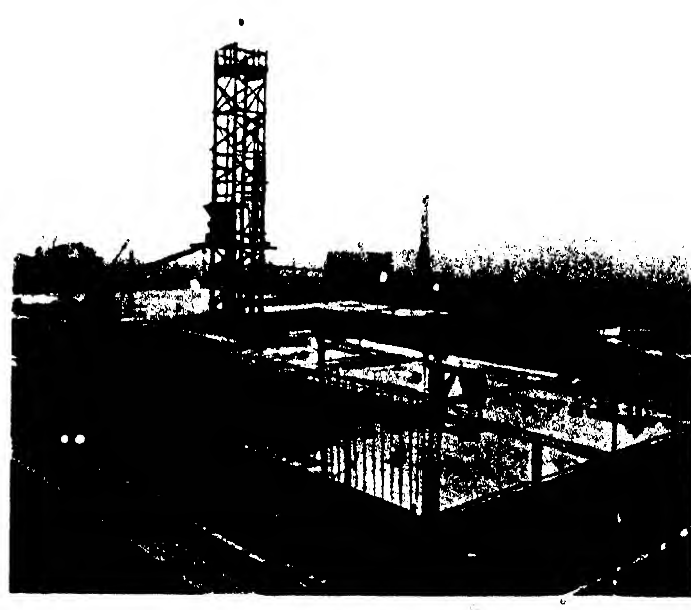
All roof trusses and roofing are carried by reinforced concrete eaves and valley beams, supported by reinforced concrete columns. All columns are carefully designed for both direct load and induced bending due to beams being fixed to the columns, and monolithic with same. The combined direct and bending stress per square inch in every case does not exceed that allowed for the direct stress alone. All beams are designed for maximum bending moments at centre (when alternate spans loaded), and maximum bending moments at supports (when adjacent spans loaded), taking into account the fixity with columns. Triangular distribution of load has been assumed as being transmitted by the floor slab to the supporting beams, which are accordingly designed. Wind pressure as specified by the L.C.C. Regulations, is taken into account in the designing of all structures.

The floor slab forming the ground floor of purifiers and catch boxes is made of mass concrete varying from 6in. to 4 in. thickness, laid to drain falls. 2 ft 6in. rail tracks are suitably embedded in them and adequately drained. The various valves and other foundations are of mass concrete. The Oxide store floor is made of 1 : 3 : 6 mixture of concrete, average 4in. thickly reinforced with ⅜ of one per cent of steel, and graded to surface drains.

Sharp bends and small angles with verticals are strictly avoided in all reinforcements, specially those diagonal bars provided for shear. The shear reinforcements mainly consist of one set of diagonal bars from point of contraflexure at the bottom of the beam to the column support at the top of the beam, instead of the common practice of providing many sets of diagonal with sharp bends at intervals. Stirrups are also provided to take up shear in beams. Columns are adequately hooped.

Construction Operations. It would be interesting to give here a concise account of the methods employed in the various construction operations, and the results obtained, to attain maximum output and speed of erection, compatible with first class work being ensured, and practicable under existing circumstances influenced by local conditions. The present day system of organisation and scientific management applicable to erection of straightforward structures on open sites, had to be considerably modified to suit a complex scheme with ferro-concrete and steel structures, elaborate drainage, intricate pipe lines for gas, steam and water, valves, lifting gears, conveyors, and railways at different levels, all involved with each other, and contiguous to existing plant.

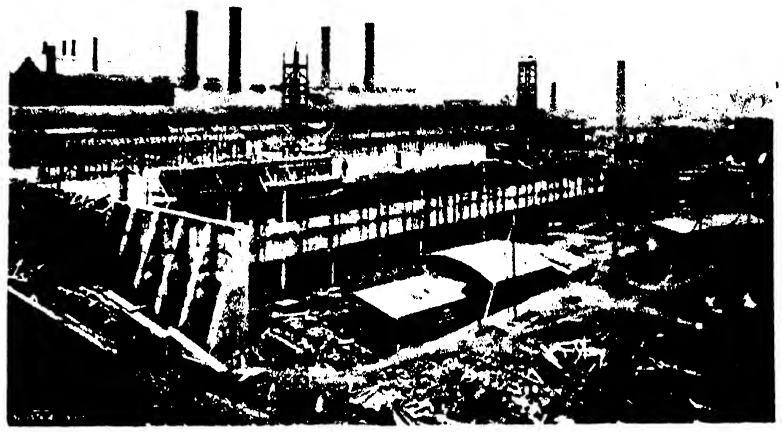
The progress of the works, started nominally in May 1921, was hampered by the Coal Strike, until August 1921, when the first consignment of column reinforcements arrived, enabling the operations to be started in full swing. By the end of the year, nearly a third of the works was completed.



Part of Revivifying Floor

In spite of the suspension of operations for two weeks at a time, due to frost, a steady progress on the average was maintained, resulting in over two-thirds of the works finished by the end of March 1922, and the remainder well on the way towards completion. It is anticipated that at this rate the whole works will be finished by August 1922, which, if fulfilled, will establish an all-round record in industrial construction in this country.

Site, Nature of Ground, Excavation. It was decided to proceed first with the construction of a reinforced concrete retaining wall (35 ft. high and about 200 ft. long), on a line denoting the division between the Oxide Store at the high level and the Purifier House and other plants at the low level. From the contour plan it will be seen that the foundation for this wall had to be excavated near the toe of a sloping embankment, a considerable portion of this slope being on the area to be covered by the Purifier House. This excavation had to be done and the soil removed so as not interfere with the two sets of purifier boxes (adjacent to the wall), required by the Corporation to be completed as soon as possible.



Works under construction taken 8th May, 1922

Difficulty was experienced in obtaining adequate area on the Oxide Store floor level to accommodate sufficient soil from the wall area, column foundations and excavations, necessary for infilling behind the wall, without placing too great a surcharge on the upper level to the vertical face excavation, required in the bank to provide the requisite width of foundation for the wall.

The excavation for the wall was commenced at the south end, the soil being hoisted to 228.25 level by means of a 5 ton steam derrick crane, mounted on travelling bogies placed parallel to and distant 5 ft. from the top edge of the slope of the bank. This arrangement allowed the use of a 75 ft. jib. The area, "clayheap" and column foundation excavation was commenced from the east end of the site, and the soil conveyed in narrow gauge train loads to within reach of the steam crane for hoisting and depositing on the upper level, to be used for infilling later on. This crane travelled towards the north and formed spoil banks.

The nature of the ground generally proved to be boulder clay necessitating the use of explosives for wall and "dumpling" excavations. The column foundations being carried to no considerable depths, were executed with ordinary pick and shovel methods. Towards the end of the wall excavation progress was made in this work by directing streams of water from hose pipes to thin horizontal beds of sand found at intervals, allowing under-

Pair of Catch-boxes in course of Erection (up to Gangway Level

cutting of the boulder clay above and proving a desirable combination when using explosives. Explosives used were 50 per cent. nitroglycerine composition charges fired by time fuses; gunpowder had not even a loosening effect, merely forming "pot" holes. Such being the nature of the ground, an elaborate method of timbering (piles, walings sheeting), the vertical face excavation for the wall was not necessary. The method used was that of raking shores through the line of wall, each requiring to be removed as work reached the point of intersection with them, and being replaced with further temporary struts to wallings from back splay of wall at the base. The excavations for drains and other pipe trenches were executed in the ordinary way.

Construction Plants, etc. The nature of the available site and the disposition of the existing works, did not permit of many facilities for carrying out the construction works. The lay-out of the mechanical and other plants required for construction operations, and the temporary buildings and sheds, was accordingly schemed to the best advantage to suit the site. It was decided to instal electrically driven plant, to eliminate any possible risk of gas explosions owing to the field of operation being so close to existing gasworks. Connections were obtained at a new sub-station of the corporation located within the gasworks. This entailed erection of over 1,300 lineal yards of cables suitable for a series of motors totalling 60 horse power wound for 440 volt, 25 cycle 3 phase, alternating current. A motor, driven 30 ins. diameter circular saw, was installed to expedite preparation of shuttering. Plant for preparing steel reinforcements consisted of two manually operated benders, and these proved capable of an output sufficient to cope with concrete placing requirements.

Temporary buildings consisted of riggers' shed, joiners' tool store, foremen's office, joiners' workshop, cement receiving shed, general store, steel preparing shed, pipe fitters' workshop, labourers' bothy, etc. Materials were generally railway conveyed, standard gauge sidings being situated on the south and east sides of the site, an area adjoining, each being reserved for unloading heavy pipe connections, valves and other castings, rail, and structural steelwork.

Mixing, Hoisting, Pouring and placing of Concrete. Concrete was mixed by means of two "Ransome" self-elevating feed hopper type mixers, each of ½ cubic yard capacity, and another mixer placed on 196.50 level near the retaining wall and later in the purifier house. Cement was stored and aerated in bins of 10 tons capacity, placed immediately behind the mixers; the requisite quantity for each batch being measured into boxes, and as required the contents of these boxes were weighed. Hoisting of concrete was done by means of two timber hoist towers, each 72 feet high, equipped with "Ransome" type automatic tipping hoist bucket, having a hoisting speed of 70 feet per minute, from a belt driven friction winch situated at bottom of towers; the concrete was discharged into receiving hoppers and conveyed by metal chutes to receiving platforms, placed within short wheeling distance of "points of fill." The actual placing was done from barrows depositing their contents where required, attention being rigidly enforced to ramming and punning around reinforcements. These methods ensured that at such points as at the junction of the reinforcing steel from four beams over a column the supply of concrete can be diminished in order to allow proper ramming to surround all the steel reinforcements, whereas if these points were filled by concrete direct from the chutes the quantity may be overwhelming to the operatives, with the result that particles of the aggregate may lodge between the upper bars and prevent proper surrounding of lower bars with concrete.

For the construction of the retaining wall one mixer was placed at 196.50 level, near the centre of the wall, to allow of filling the base and bottom splay concrete direct from narrow gauge travelling side tip wagons running parallel to face of wall. The upper portions of the wall were filled by hoisting skip wagons to 228.25 level, and discharging their contents to timber chutes placed on slope of bank, concrete being collected on receiving platforms placed between counter-forts. In addition to cement storage close to mixers, a cement receiving shed was constructed centrally between the mixers, and capable of holding a sufficient quantity to permit of 28 days test before using.

The quantity of measured placed concrete in one week of 49½ hours, amounted to 200 cubic yards, this work being to requisite thicknesses, a large proportion of which (in floor slabs), necessitated "screeding" off to depth gauges and subsequent tooling to provide desired finish.

Materials Tests. Concrete aggregate consisted of special steel slag crushed to pass a ¾ in. mesh. Sand from local pit supplies proved to bulk well with aggregate. Results from crushing tests on 6 in. cubes at 28 days and taken from batches of 1 : 1½ : 6 mixture in course of depositing showed 3,330 lbs. square inch. Cement used consisted entirely of English Portland Cement of medium setting standard. No water-proofing compositions were added to concrete.

Shuttering. Throughout the work the shuttering used consisted of 1¼ ins. thickness, white pine butt edge jointed boarding, machine dressed on both faces and edges. For slabs the ducking was laid on 6 ins. by 3ins. joists, supported by runners and struts wedged upon timber soles well embedded in the ground. For vertical boarding the shuttering was supported by 6 ins. by 2 ins. profiles placed on edge and fixed above the concrete gangway level by runners to inner profiles, which were again racked between themselves to form a rigid structure, no bolts were placed from outer to inner shuttering through walls, which were later to be subjected to water and gas-tight tests. Shuttering for beam soles were constructed in timber of 3 ins. thickness; this allowed of the use of fewer struts—a considerable advantage in providing working space for handling large diameter gas pipe connections. Ample provision was made for washing out all beam forms and wall boardings by means of large sized apertures. It was considered advisable to leave the decking of slabs for a period of three weeks after concreting before striking; vertical boarding was struck four days after concreting, and beam soles were allowed to remain with all supports in position for six weeks before striking. The various castings, *e.g.* outlet and inlet pipes, oxide discharge valves, embedded in floors, were supported independent of floor shuttering, these supports being allowed to remain in position for some considerable time after striking slab shuttering. Great care was taken to have all seams and interstices in shuttering closed before commencing concreting, with the result that large areas of the work required no further treatment to give a satisfactory skin finish.

(*To be continued.*)

The British Industries Fair, Birmingham

Concluding survey of some of the leading exhibits. The first survey appeared in our June issue

THE *Heatly-Gresham Engineering Co. Ltd.*, exhibited some very fine examples of the most up-to-date types of oil engines of small power. In line with modern practice these are of the vertical type, with totally enclosed crank-chambers, thus keeping all moving parts carefully guarded from the inroads of dust and foreign matter. Lubrication is automatic, and the sets are very simple to operate—the ease of operation having been reduced to a very fine point. By means of a very small modification to the design, the engines can be run on town gas, while among the oil fuels which can be used with equal satisfaction may be named petrol, paraffin, benzole, kerosene, alcohol, and indeed any oil of a similar nature.

It will be noted that the camshaft drive is by means of a silent chain, this divergence from the usual gear drive having proved over the past 10 or 12 years to possess many advantages. Failure by breakage is practically non-existent, whereas, as is well known, machine-cut gear wheels are apt to fail in this manner. In the case of the chain, the strain is taken on practically half the total number of teeth, whereas with gears one tooth alone has to bear the whole of the load.

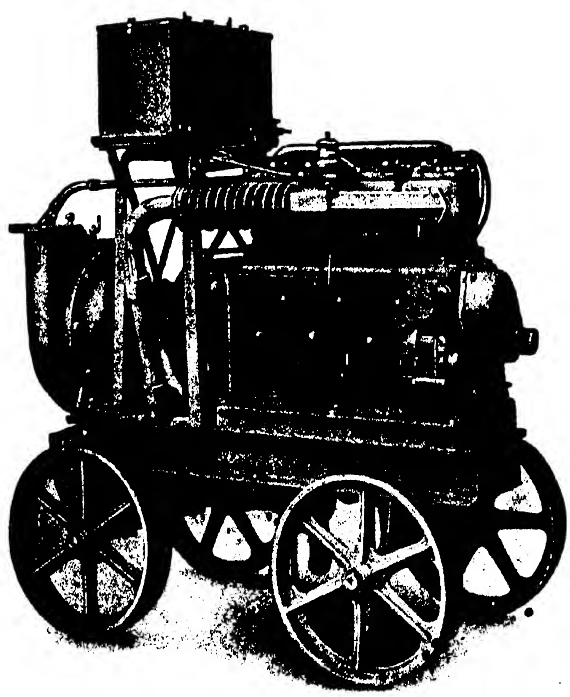
In a similar way the magneto is also chain driven, and this method, as in the case of the camshaft, has proved the most reliable that can be devised.

On their larger engines the latest word in magnetos can be seen, these magnetos being fitted with an automatic spark intensifier which comes into operation when starting up, the action not only intensifying the spark, but also retarding it. The device automatically disengages as the engine runs up to speed, and by its use even large engines can be started up by hand, as it is only necessary to crank round slowly. Indeed, it is unusual if the engine does not start at the first pull up of the handle.

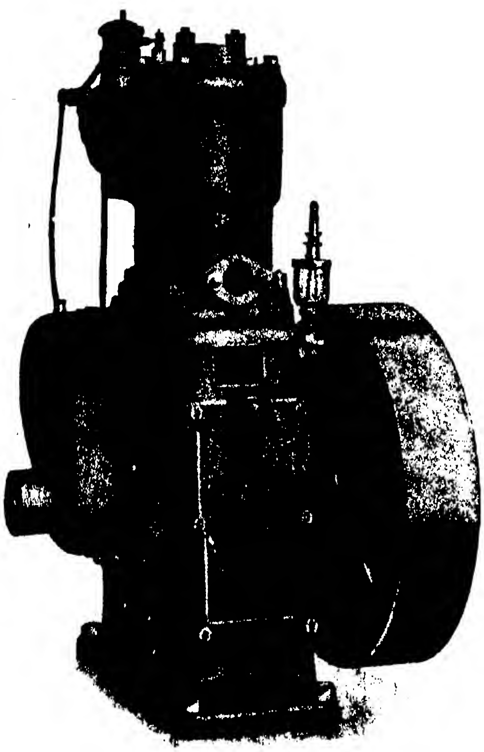
In all types the speed is controlled by a sensitive yet robust centrifugal governor acting on a throttle valve, which admits fuel in proportion to the load demanded from the engine. In many cases the speed does not vary as much as 2 per cent. between full load and no load.

A further point to which attention might be called is the use of the 4-stroke principle, as for stationary and portable engines; this has much to commend it over the 2-stroke principle. With the 4-stroke principle it is only necessary to keep tight the valves and piston rings, while in the case of 2 stroke engines there are not only these points, but also the various joints of the crank chamber, and particularly the apertures through which the crankshaft must pass. It is, of course, a misnomer to say that the 2-stroke is a valveless engine, because it is always necessary to have a valve to control the air inlet, and another to control the fuel injection.

Unlike many engine manufacturers, the Heatly-Gresham Engineering Co. Ltd. produce in their own works practically every component part of their engines. The forgings entering into the composition of these engines are made in dies by the most up-to-date methods, lessening production costs



Engine coupled to Centrifugal Pump



Rational Single Cylinder Engine

and ensuring interchangeability. In the same way the castings are made on the latest machines known to Foundry science, quantity production and uniformity of quality and size being striking characteristics. Added to these points is the machining of all parts accurately to jigs, and within defined limits, thus ensuring interchangeability of the finished items, so that the fitting and supply of spares is simplified to the greatest possible degree.

Messrs. Ashworth, Son & Co. have a very representative stand of weighing instruments, ranging from a diamond balance to a weighbridge of 20 tons capacity.

The latter is specially constructed to deal with all types of road vehicles, no matter what the concentrated weight on the back axle may be, of all types of motor or steam wagons—an unique feature is that it will weigh a load of 10 or 12 cwt. with equal accuracy as 20 tons.

On the stand are displayed photographs of weighbridges, constructed to carry the largest and heaviest locomotives yet made, with weighing capacities of over 100 tons, which makes the 20 ton weighbridge, shown in the front of the photograph of stand, look insignificant.

For use with these weighbridges are pillars and steelyards which record the weighings on tickets; this printing device is quite new, as it embosses the weight on the cards used, giving clear, bold figures. Among the exhibits are two kinds of automatic dial indicating mechanisms, which instantly shows the weight of loads on a graduated dial face—these are largely used in collieries and cattle markets.

There is a very fine display of platform weighing machines, fitted with improved types of steelyard, in all ranges and types, suitable for every trade.

A selection of counter scales are shewn finished in the very best possible way with hard gold hygenic paint, which can be readily wiped without deteriorating the first-class finish, and are an acquisition to any tradesman's counter.

Years ago chemists used to go to Germany for chemical balances, but Messrs. Ashworth & Son can now fill these requirements with suitable balances, a number of which are exhibited by them.

Quite a small weighing machine is exhibited, called a Crane Weigher, and it seems incredible that so small an instrument can be slung up on a crane and weigh accurately from a few pounds up to say 5 tons or more.

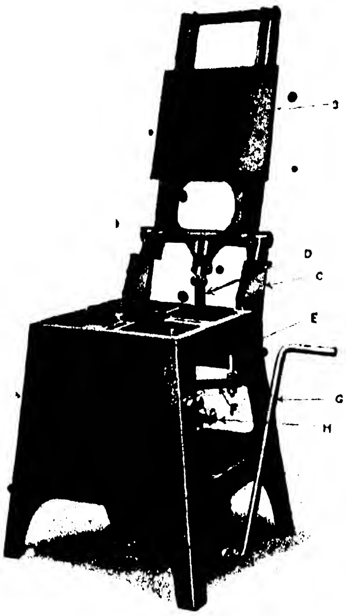
A further review of the exhibits will appear in our next issue.

The exhibit of *The "Pneulec" Machine Co. Ltd.*, aroused considerable interest. Foundry equipment including their electrically operated jam jar moulding machines and roll-over core-making machines received particular attention. The "Pneulec" Tamper Moulding Machine is somewhat of a new departure.

It has been designed specially for the making of light repetition castings where the moulds required are comparatively shallow, say up to 6in. deep, but whilst this class of work is most suitable, it can be still used for making moulds which have to be rammed by hand to a large extent, *i.e.*, it can also be used as an ordinary hand ram machine.

Reference to the illustration will show that the machine consists of a stand (A), which is cast in one piece, and to which is attached the pressure plate (B), by means of the brackets (C), which are adjustable vertically. The pressure plate is pivoted at one end in the brackets (C), and can be swung downwards on to the top of the mould to give the tamping action. The weight of this pressure plate is counterbalanced by the strong spring (D), which can be adjusted to any tension, thus varying the strength of

Messrs. Ashworth, Son & Co.'s Stand



Pneulec Moulding Machine

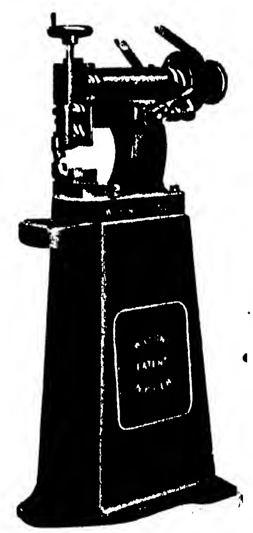
the blow given by the pressure plate. The pattern is withdrawn by means of the lifting rods (E), which engage on the edges of the moulding box. These rods are carried on adjustable arms (F) in order to suit different sizes of boxes. The lifting rods are raised and lowered through the medium of a link motion by means of the hand lever (G). When the mould has been rammed and the pattern is ready to be withdrawn, the lever (G) is pulled gently towards the operator until it engages with the spring catch (H), which holds the lifting apparatus stationary whilst the operator takes the mould away. The counterbalancing effect makes the machine surprisingly easy to manipulate, and it is astonishing how hard a mould can be rammed with the slightest of efforts.

The Tangent Tool Engineering Co. Ltd. were showing a number of new tools. Their Tangent Rod Shearing Machine, illustrated, will be found of great utility for cutting off round or square rods, especially so in such cases as in ferro-concrete work, etc., where quantities of a given length are required. The shearing is effected by means of a pair of hardened and tempered circular dies, one of which is fixed in the frame, the other being carried by the movable arm of the machine. The opposing faces are ground, and are kept in contact by a hardened and ground central pin, which also serves as the fulcrum. The dies each have four slightly tapered holes of different sizes to suit different sizes of stock, and if care is taken to see that the work is inserted in a hole most nearly approaching the size of the stock, a clean, square and undistorted shear is obtained. The dies are quickly removed for regrinding or replacement. The capacity of this machine is up to $\frac{7}{16}$ in., and the weight is only 17 lbs.

A great labour-saver for engineers is Wilson's Patent Nibbling Machine for the rapid cutting of metals, exhibited by *Messrs. J. B. Stone & Co. Ltd.* Amongst the many claims made for this machine we noted that it will quickly cut or perforate to any design all kinds of sheet metal. The traverse of cut is in any direction, following closely the outline of a template or graph without leaving the edge compressed. It is instantly adjusted to different gauges of metal, and will cut at an average speed of 18 inches per minute. It is an indispensable and economical unit for the

Tangent Rod Shearing Machine

making of cast steel gauges, and is ready at any moment to cut one or a quantity, and is so simple in con-



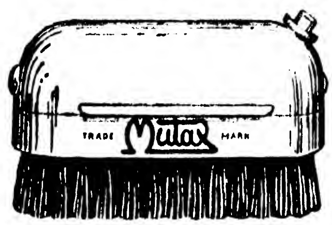
Wilson's Nibbling Machine

struction that it can be operated by a boy. The machine can be run at 300 revolutions per minute, and the job needs no filing after leaving the machine. It takes very little room and requires under one-half horse power.

Kendrick Lamp

As real efficiency is only obtained by local lighting, every works manager will appreciate the economies effected by the Kendrick portable (electro-magnetic) lamp. The Kendrick lamp exhibited by *The Neale Magnet Construction Co. Ltd.*, consists of a combined lampholder and electro magnet, which is suited to any direct current circuit, and adheres firmly to any iron or steel surface whether or not

it is covered with paint or enamel. It can be attached in any position so as to throw the maximum light on the work in progress whilst leaving both hands free. A push switch in base facilitates rapid removal without putting out the light. *Our illustration shows the Kendrick Lamp in use on a motor-car repair job.*



Mutax Petrol Brush

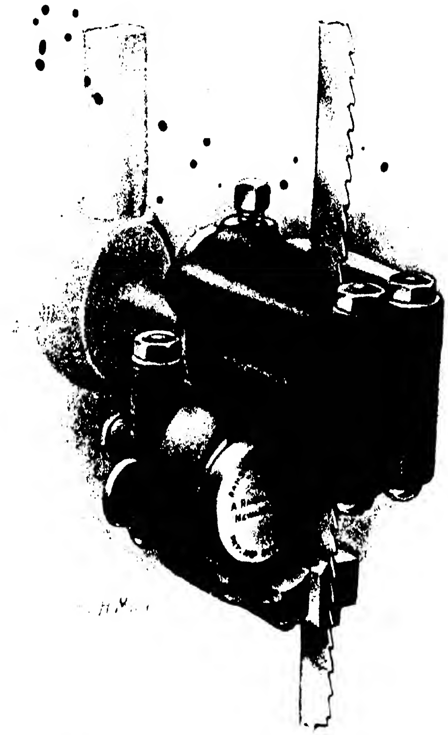
A new and entirely original invention is the Mutax Petrol Brush exhibited on the stand of the *Mutax Co.* By its use dry-cleaning can be done at home, cheaply, efficiently, and without risk. It consists of (1) a scientifically designed pure hog-bristle brush and (2) a white metal alloy container, into which this brush is clamped. A simple valve device allows the petrol or other cleansing spirit with which the container is charged to steadily percolate down the bristles as the brush is used. And here is its advantage over all other methods of petrol cleaning—only clean fresh spirit comes in contact with the fabric, and the brush itself is never dirty. It is leak-proof, neat in appearance, and convenient to handle, while its total cost is no more than that of a good ordinary clothes brush of equal quality.

The Ransome & Newell patent Self-aligning Band Saw Guides and automatic Saw Sharpener for small circular and narrow band saws were the two items exhibited by *Messrs. A. Ransome & Co. Ltd.*

The chief feature of this patent guide is that the jaws, or guiding parts, instead of being rigid as in all other guides, have a swinging movement which allows the back of the saw to swing freely while the teeth are held practically stationary. It will readily be understood that as the guide moves freely with the saw it is impossible to twist the saw in the guide. The back of the saw blade swings freely throughout its entire length between the saw pulleys, instead of having to withstand the severe twists and strains to which it is subjected by the use of a rigid guide.

As the saw blade cannot bind against the guide plates, heavy side friction is entirely eliminated, and thus the wear on the saw and the guide plates is very greatly reduced. An experience of several years has proved beyond any doubt that the use of these guides results in a very large reduction in saw breakages. The swinging movement automatically compels the saw blade to follow the true line of pressure and any tendency of the saw to deviate causes the guide to react upon it, thus immediately correcting the deviation. For ripping and resawing, and for all work with templates, or sawing on centres, it is unequalled, and does work which must be seen to be believed possible.

For curved work the operator is enabled to force the saw round the shortest curves without kinking or straining it, and it is therefore invaluable for pattern shops and for general work. On a machine equipped with them the operator can saw close to the line without spoiling the work or necessitating a lot of hand finishing, as the saw will cut perfectly true from top to bottom whatever the depth (see illustration). The greatest care is taken in the manufacture, and each detail is properly designed and proportioned for the work it has to perform.



Self-aligning Band Saw Guides

Band Saw Guide on Machine

Low Temperature Carbonisation (iii)

BY DAVID BROWNLIE
B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min.E., Mem. Am. Soc. M.E., A.I.Mech.E., etc.

In this the third of our series of articles on Low Temperature Carbonisation, Mr. Brownlie deals with the pioneer work of Messrs. Sutcliffe, Speakman & Co. Ltd.

THE Pure Coal Briquette process of carbonisation consists essentially in grinding the coal and mixing it with ground coke breeze, non-coking coal, or coal subjected to a suitable preheating treatment, so as to prevent it swelling on carbonisation. The mixture is then briquetted without a binder, at high pressure, in special briquetting presses, forming what is known as a pure coal briquette, because no pitch or other material is necessary to bind it together. These briquettes are of high quality and are sold in competition with the ordinary briquettes.

The chief point of interest, however, is that such special briquettes can be carbonised without any expansion taking place during the process, and the residual fuel, even when containing only 2 per cent. volatile matter, has not only the usual properties of being smokeless and burning with a high emission of radiant heat, but also ignites without difficulty, like coal or charcoal. The reason of this remarkable and valuable property seems to be in the extremely fine granular condition of the carbonised briquette, which under the microscope is seen to bear a strong resemblance to charcoal. In this connection Fig. 3 will be of great interest.

Messrs. Pure Coal Briquettes Ltd., was formed by the late Lord Rhondda, and has as its constructional and consulting engineers Messrs. Sutcliffe, Speakman & Co. Ltd., of Leigh (Lancs.), who are specialists in the manufacture of briquetting machinery. The research and development of the Company are under the charge of Mr. E. R. Sutcliffe, Managing Director of Messrs. Sutcliffe, Speakman Ltd., and Mr. Edgar C. Evans, head of the Lord Rhondda Research Laboratories, Llwyngpan, Glamorganshire, and more than ten years of experiment and research have been spent in bringing the carbonisation process to its present successful stage.

In the preparation of the Pure Coal Briquettes the coal is first washed, as usual, so as to reduce the ash content to 5-6 per cent to give an increased gas yield and produce a uniform quality of smokeless fuel. The coal is then ground and mixed intimately with the material most suitable for preventing swelling — which is generally coke breeze. At the same time a very large amount of cheap fine slack and coal dust can be worked into the mixture. The extent of the grinding depends on the quality of the fuel required. If carried out as far as to pass through a 30-40 mesh (1,000 holes per square inch of mesh), the resulting fuel is of high quality with an extremely fine grain, and is in fact an artificial anthracite. For ordinary industrial purposes such an amount of grinding is not necessary, but generally speaking, the finer the grinding the better is the quality of the fuel produced.

The mixture is then passed through the "Ovoid" patent briquetting press of Messrs. Sutcliffe, Speakman & Co. Ltd., in which the pressure on the briquettes is 10 tons per square inch. The resulting ovoids are extremely hard, and can be charged into an ordinary gas retort or coke oven for carbonisation without damage, this form of briquette being the most suitable for carbonising and also for subsequent sale as smokeless fuel. The briquettes can, of course, be made in any shape from ovoids to blocks 10inch. by 7inch. by 5inch., weighing 15 lbs. each.

It is claimed that these briquettes have a number of advantages over the ordinary type of briquette made with a binder of pitch or other material. They are stated to be much harder, and equal in hardness to lump coal, so that they stand transport and handling better, and also do not soften in hot countries. Further, they burn with a higher emission of radiant heat, without smoke, and it was in fact the peculiar burning properties of these briquettes that led to an investigation as to their behaviour under carbonisation.

With regard to briquetting machines Fig. I. represents the "Emperor" press briquetting machine made by Messrs. Sutcliffe, Speakman Ltd., and is the largest briquetting press in the world, having a capacity of 40 tons per hour, and working at a pressure of 2 tons per square inch.

The carbonisation process has the great advantage that the operation can be carried out either in special retorts, or in the existing gas works retorts or coke ovens.

Taking first the question of erecting an entirely new plant, the retorts are simple in construction, and, even more valuable, will carbonise a very large amount of material at a time. As already stated, the briquettes have the peculiar property that they do not expand or swell on carbonisation, and in fact, a slight contraction takes place. As pointed out in the introductory article, this question of expansion has always been one of the troubles of low temperature carbonisation. The residual carbonised fuel briquette by this process is, however, exactly the same size and shape as the original pure coal briquette. The retort is of the continuous vertical type, with suitable automatic charging and discharging mechanism, and again, because of the non-expanding properties of the briquettes, the contents are heated by the direct passage of a current of heated gas through the charge of briquettes, and external heating, as used in almost every other system, is not necessary. The general lay-out of a plant designed to handle 1,000 tons of coal per 24 hours is given in Fig. 2.

Four retorts are shown, each of them having a capacity of 250 tons per day. These retorts consist essentially of a vertical cylindrical chamber lined internally with firebrick surrounded by heat insulating material, and this again is surrounded with cylindrical gas-tight steel plates.

The retorts are equipped with two regenerators, of the ordinary type, filled with chequer bricks. They are used alternately in the usual way, one regenerator being heated up while the other is being used for heating up the gas used as a heating medium. The

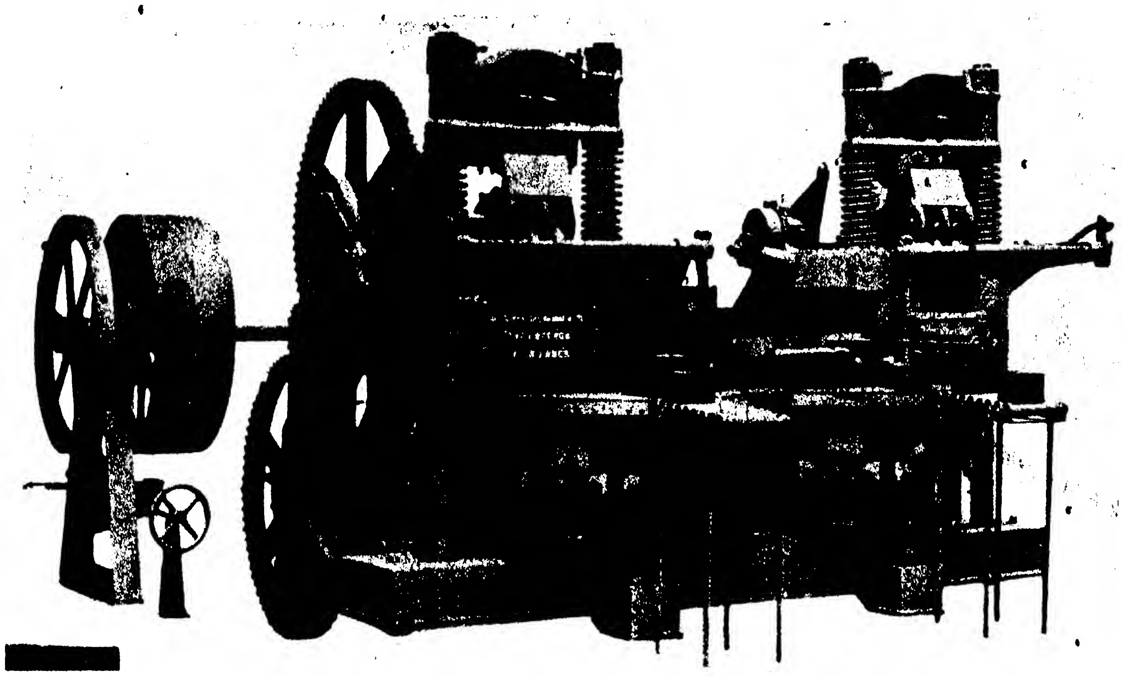


Fig. 1. "Emperor" Briquetting Press — Sutcliffe, Speakman & Co. Ltd.

heating of the regenerators is performed by producer gas which has been freed from tar, ammonia, and by-products. This gas is burned at the bottom of the regenerator, and the products of combustion pass through the chequer bricks, raising the temperature to the required point. During this period, the regenerator is open to the chimney.

When the desired temperature has been attained, say 1,650 deg. F., the chimney damper is closed, the gas and air supply to the burners are shut off, and the communication damper to the retort opened. Communication is then made with the gas main. Cool gas is passed through the regenerator, becoming heated in its passage, and goes directly into the retort. The sensible heat acquired by the gas in its passage through the regenerator is imported to the coal, carbonising the charge, and reducing the volatile content to the point required.

During this period the other regenerator is being heated up, the various valves, dampers, etc., being altered so as to reverse the passage of gas, air, and products of combustion simultaneously with the first regenerator.

There are no engineering or mechanical difficulties to be faced in this system, which, for all practical purposes, can be compared with a blast furnace equipped with regenerators, but instead of the regenerative stoves being used for heating air, as is customary in blast furnace practice, they are in this case used for heating inert gas. The whole carbonisation process is of a fractional character, the temperature gradually increasing as the charge travels downwards. That is to say, the raw coal is first subjected to low temperature distillation in the top portion of the retort, the temperature of the gases leaving being about 400 deg. F., and all the valuable liquid products driven off, and the low temperature fuel is then submitted to high temperature carbonisation in the bottom of the retort. The carbonisation is almost complete, as a while only about 2 per cent. of volatile matter being left in the briquettes, and the gaseous and volatile products pass away out of the top of the retort into the usual by-product plant, whilst the carbonised briquettes

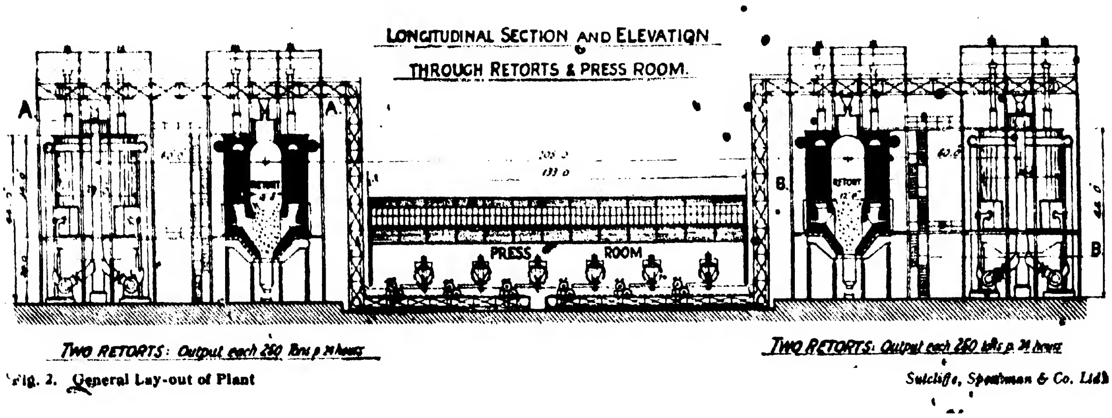


Fig. 2. General Lay-out of Plant — Sutcliffe, Speakman & Co. Ltd.

are emitted continuously from the bottom of the retort. A small retort dealing with 13-14 tons of coal a day has been in continuous operation in Leigh for the last five years, and an experimental internally-heated retort on similar principles, erected in India by Mr. Edgar C. Evans, proved itself capable of carbonising coal at a rate which was equivalent to treating 10 tons a day. The design has therefore had a thorough small scale trial.

It is stated also that, whilst the retorts are of simple construction, without any expensive and elaborate flues and brickwork, as with most other carbonisation processes, because of the internal and intimate heating the fuel required to heat the retorts is considerably less than the usual figure of say 15 per cent. of the coal carbonised.

As seen from the drawing, Fig. 2, the general process consists therefore in washing the coal, partially drying, pulverising and mixing with pulverised coke breeze, or with non-caking coal or preheated coal, converting the mixture into briquettes, and carbonising these at high temperatures by means of internal heating with superheated inert gas, whilst the gaseous and liquid products are treated in the usual manner as in the gasworks and coke oven industries. The process is, therefore, strictly speaking, not low temperature carbonisation, but rather a special combination of both low and high temperature carbonisation, in which the residual fuel has all the properties characteristic of a low temperature process.

The advantages claimed for a large scale installation are :—

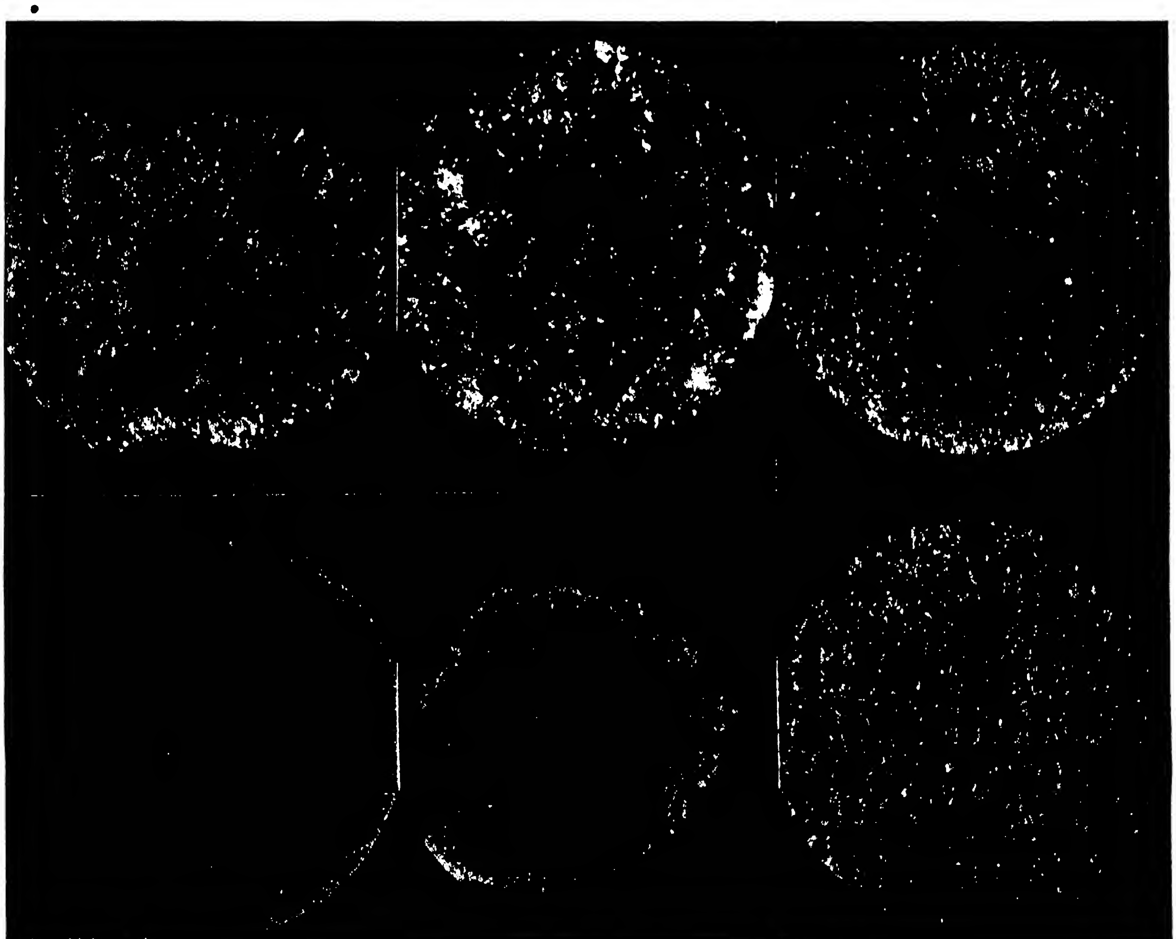
(1) *Low Capital Cost.*

It is maintained by the inventors of this process that to make a smokeless fuel proposition pay on a large scale, the cost of the plant must be less than existing carbonising systems, and it is claimed that the pure coal briquette installation is less costly per unit of output than any other process, and much less than the present expensive gas works and coke oven equipment. For an installation to carbonise 100 tons a day the retorts would cost £15,000, and together with drying, grinding and briquetting plant, with complete by-product recovery, the total cost would be less than £50,000, allowing £25,000 for the by product plant and £7,000 for the briquetting and drying plant.

(2) *High Capacity.*

The output of a unit retort will be 100 tons a day of 24 hours, and designs are being prepared for a retort to handle 250 tons of coal a day. There is no reason why huge retorts of 1,000 tons a day capacity

1 2 3



4 5 6

Fig. 3. (1) Gas Retort Coke magnified 5 diams. (2) Gas Retort Coke magnified 7 diams. (3) Blast Furnace Coke magnified 5 diams. (4) Activated Carbon for Gas Absorption magnified 10 diams. (5) Pure Coal Briquette, Carbonised, magnified 15 diams. (6) Oak Charcoal, Cross Section, magnified 10 diams.

should not be constructed. It is also maintained that any successful smokeless fuel process must have a large yield per retort per day.

(3) *Low Working Costs.*

It is claimed that the working costs are low. As regards labour, taking three shifts of eight hours each, and labour at 12s. per man per shift, the cost for a plant of 100 tons of coal per 24 hours, for the briquetting, grinding and carbonising plant, would amount to less than 2s. per ton of coal. The power required for the above plant of 100 tons of coal per 24 hours would be 150 H.P. which, at a cost of 0.75d. per H.P., would be 2s. 3d. per ton of coal.

Taking also the wear and tear as 1s. 6d. per ton, and the interest and depreciation as 15 per cent., the total cost of production of the carbonised material would be not more than 11s. per ton, of which 3s. 6d. to 5s. per ton is required for the preliminary drying, grinding and briquetting treatment.

(4) *Low Cost of Raw Material.*

The raw material used for carbonisation in the first place contains 20 per cent. of coke breeze, which is extremely cheap, being practically a refuse product. For years it was a drug on the market, and the pure coal briquette process, therefore, is valuable in finding an outlet for coke breeze. Also, as already stated, much cheap non-caking and fine coal can be mixed with the coal, so that the final mixture is a cheap raw material.

(5) *Perfect Control of Temperature.*

These retorts can be worked at any required temperature from 900 deg. F. to 1,850 deg. F. (480 deg.—1,000 deg. C.), according to the coal and the products required. The temperature can also be maintained constant to within 100 deg. F. because of the large volume of heated gases.

(6) *Gas Yield.*

On account of the small amount of volatile matter left in the residual fuel the yield of gas is comparatively high, being about 10,000 cubic feet of rich gas (550 B.Th.U) per ton of coal.

(7) *Good Yield of Valuable Liquid Products.*

The coal in its passage through the retorts is only slowly and gradually heated up to the maximum temperature, and because of the porous nature of the briquettes, the liquid products are expelled rapidly with the minimum of "cracking." With average bituminous coal the yield of tar is 15–25 gallons per ton, depending on the coal treated, whilst the motor spirit is 3 5 gallons, as against about 10 gallons of tar and 1–2 gallons of motor spirit with the high temperature processes.

(8) *Maximum Yield of Sulphate of Ammonia.*

Exhaustive tests on the small scale plant already mentioned show that, because of the natural porosity of the briquettes, the yield of sulphate of ammonia is 50 per cent. greater than in ordinary high temperature carbonisation processes. As an example, a given coal carbonised as usual in a gas works retort gave a coke containing 1.44 per cent. nitrogen, whereas when mixed with 20 per cent. coke breeze and submitted to the pure coal briquette process the residual fuel only contained 1.00 per cent. nitrogen. The yield of sulphate of ammonia per ton of coal is claimed to be 38 40 lbs., that is about 50 per cent. more than the high temperature processes.

(9) *The Residual Fuel.*

The residual fuel can be varied greatly in properties, according to the fineness of the grinding and the proportion of coal and coke used, from a smokeless domestic fuel to a blast furnace coke superior to coke oven coke.

The carbonised briquettes have remarkable free burning properties, and even when carbonised at the highest temperatures, up to 1,800 deg. F., will ignite and burn readily in a household fire just like coal. The fuel resembles charcoal, not only in structure and appearance, but also in its method of combustion. It burns right through to the centre, with a very hot fire, until nothing is left but ash. It is also very hard and dense, equal to anthracite in this respect, and will stand the most severe conditions of transport and handling. The analysis of a typical sample, using unwashed coal of average quality, is fixed carbon 84.5 per cent., volatile matter 1.3 per cent., ash 10.6 per cent., water 3.5 per cent., and sulphur 1.9 per cent., with a hardness of 98, equal to the best Durham coke.

At the present time gas coke in London is about 50s. per ton, whilst anthracite is 92s. 6d. It is claimed that this low temperature fuel is equal to anthracite in every respect, and that a conservative figure for its value is 75s. per ton. Also that it will replace coal for any operation, and for example, works perfectly well in an anthracite stove.

As already stated, another advantage claimed for this process is that it can be used direct in place of coal in existing gas works retorts or coke ovens. Because of the high compression and dense nature of the briquettes a much larger charge, equal to nearly 50 per cent., can be got into a gas retort or coke oven. This increased capacity is also aided by the fact that, because of the non-expansion, there is no need to leave room in the retorts or ovens to allow for expansion as in the case of raw coal. In the gas works process, in the case of horizontal and inclined retorts, the existing charging mechanism can also be utilised. For vertical continuous retorts minor alterations are necessary in the charging mechanism, but this would not be an expensive matter.

The cost of coal drying, grinding and special briquetting plant to handle 100 tons of coal per 24 hours is approximately £7,500, and as already stated, the total cost of the process works out at about 3s. 6d. per ton. It should be noted that less gas is given off per ton of fuel, because of the addition of 20 per cent. of coke breeze, but more gas per retort because of the 50 per cent. increased capacity. When the process is carried out in coke ovens the product is claimed to be much superior to ordinary foundry coke.

Messrs. Sutcliffe & Evans, the inventors of the process, dealt with this point at considerable length in a paper delivered a short time ago before the Society of Chemical Industry. They stated that a fuel of extremely high specific gravity, as compared with furnace coke, and with a combustibility of the same order as that of charcoal, offered revolutionary possibilities in blast furnace practice. On the basis of the results obtained in the case of charcoal furnaces they claimed that such a fuel, when used in blast furnaces, would effect the following results:—

(1) The capacity of the furnace would be enormously increased.
(2) It would be possible to use furnaces very much lower in height and smaller in dimensions than those now in use, and yet which would give the production of existing coke fired blast furnaces.
(3) The heat losses in a blast furnace using a fuel of this type would be very much lower than those of the ordinary coke fired furnaces.
(4) An enormous saving of fuel was foreshadowed. It is well-known that charcoal furnaces, working on pure coal, have startling low consumptions of fuel. With a fuel of this type the authors see no reason why Cleveland Ore, which would not be

smelted under present conditions with less than 21 cwts. of coke per ton of pig, should not ultimately be treated with as low a quantity as 12 cwt.

(5) This opinion, of course, cuts at the root of all modern theories of blast furnace practice. The authors realise this and went into detail into the views elaborated as the result of the researches of the late Sir Lothian Bell, and pointed out that owing to the new factors introduced by the combustibility of the new fuel, it would be necessary to completely revise the conclusions come to by Bell, and the opinions now held by blast furnace experts.

No serious attempt was made in the discussion following this paper to criticise the proposals, but the general opinion come to by some of the leading experts of the country was that the paper was of an epoch-making character, and that a fuel of the type made by this process offered revolutionary possibilities in the future of industry.

We understand that a very large plant will shortly be erected in Lancashire, and of the various processes of the carbonisation of coal now under consideration the pure coal briquette process is certainly not the least interesting.

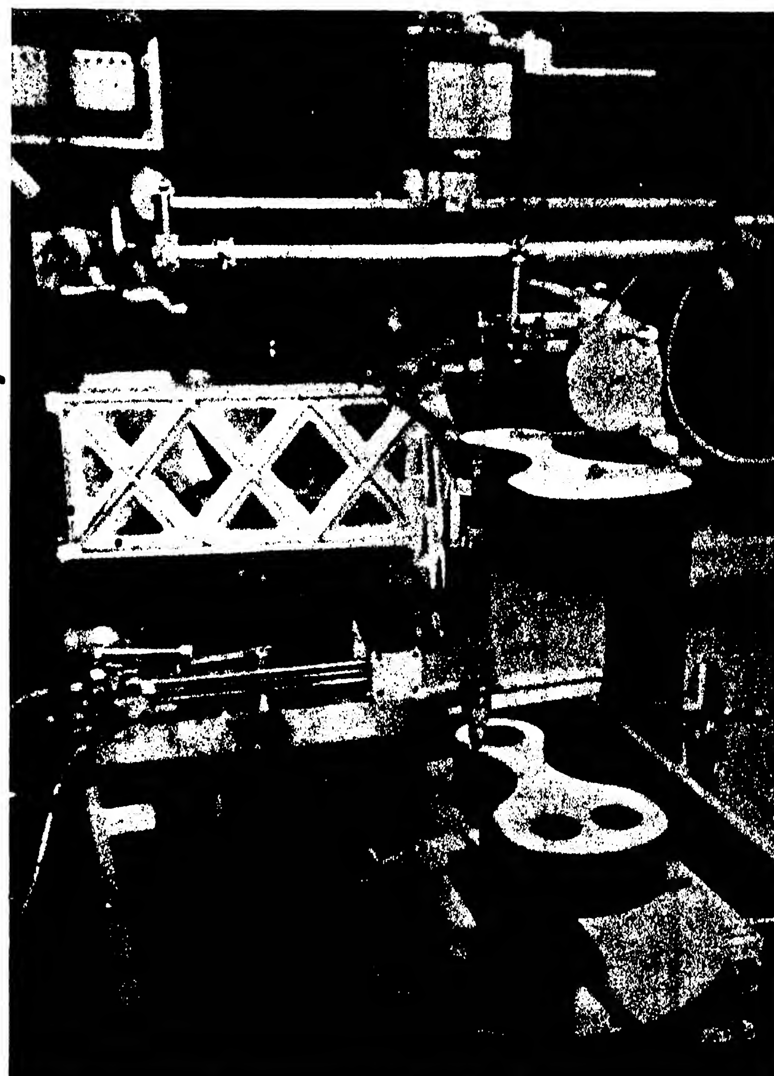
(To be continued)

The Godfrey Oxygen Jet

In this article the author describes an automatic process for the cutting of steel plates, the employment of which leads to a great economy of oxygen and acetylene.

QUITE a deal of interest has recently been shown by manufacturers and others dealing in steel plate, with regard to the development of the cutting of steel plate by means of the oxy-actylene blow-pipe. Anyone familiar with the cutting of such material knows that when the hand process is employed a great deal more oxygen and acetylene are required than if the plates were cut by an automatic process; the reason for this is quite evident. When the hand blow pipe is employed the operator must necessarily adjust the flow of his gases at the joint of work; this necessarily means that, although a small time may be consumed, nevertheless a waste of oxygen and acetylene occurs while this adjustment is being made. The question of speed and quality of cutting also enters into the matter; quite naturally the operator cannot hold as steady a torch as can be accomplished by the mechanical method; the result being that the cut is jagged with the consequence that a liberal amount of excess metal must be left on for finishing.

The Godfrey machine has been developed to be entirely automatic in its cutting operations. It has been so designed that any piece of work which it is desired to fashion can readily be duplicated accurately. This machine is fashioned on the principle of a machine-tool and resembles a machine-tool in its working operations. When designing the oxygen jet cutting apparatus, Mr. Godfrey's investigations led him into the study of the gas pressure, the design of the blow-pipe and the mixture of the gases. It was found



Irregular shaped piece 3" thick, 15½" long, and 8" wide at the broadest part

Total Cutting Time 12 minutes

that these were the important items around which a successful operation of the oxygen cutting apparatus revolved. With regard to the gas pressure it was found that a much lower pressure could be used than was necessary when using the hand torch.

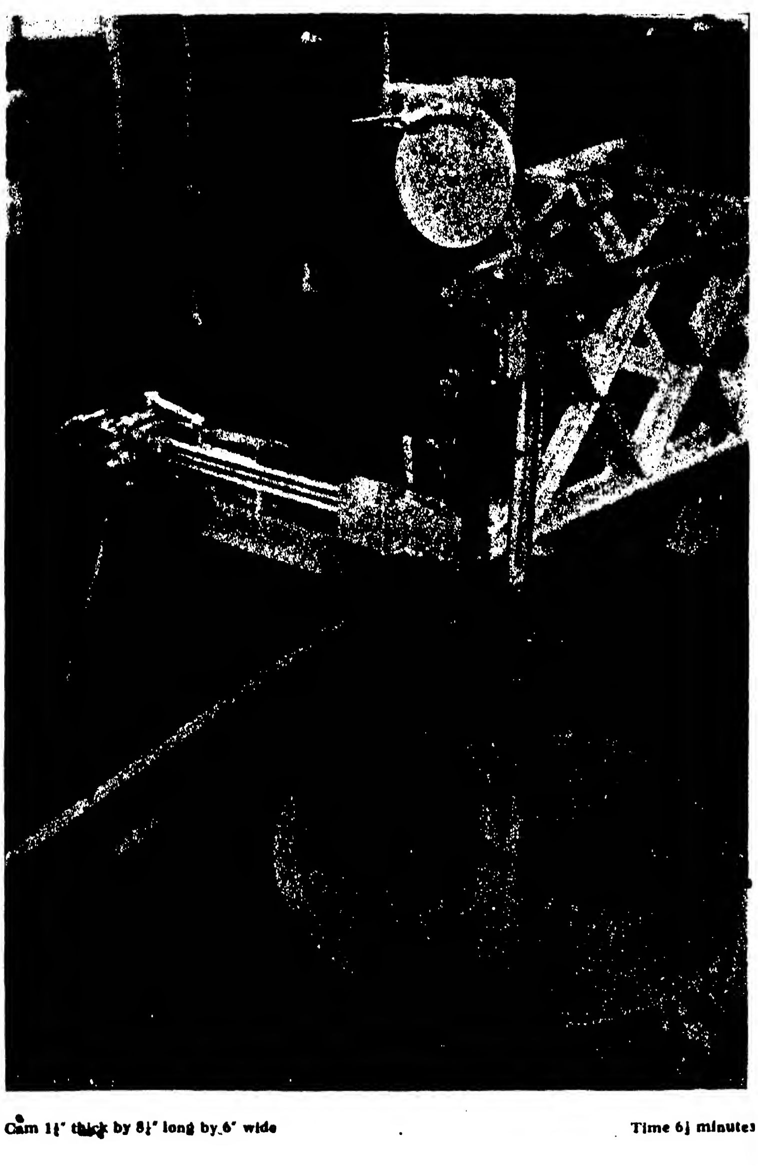
The design of the blow-pipe is unique, in that the interior along which the gases pass is rifled similar to the barrel of a shooting iron, tending to impart to the mixed gases a whirling action. The whirling action of the mixed gases reduces the heating cone in length to approximately ¼in., at the same time giving a cut approximately $\frac{1}{16}$in. wide. The result of these two features has been to give the plate, when cut, clean and sharp edges which can readily be understood to be of advantage. The temperature of the oxygen was found to have considerable effect on the cutting qualities of the gases. For instance, it was learned that using the oxygen direct from the cylinder, the cutting action in cold weather was not so good as it was in warm weather; consequently after considerable investigation it was determined that pre-heating of the oxygen resulted in better operation of the oxygen jet cutting apparatus, not only as regards the quality and operation of the cut, but also by increasing the cutting speed.

The Godfrey machine was the first oxy-acetylene cutting apparatus of its kind to be marketed, having the combined advantages of the oxy-acetylene cutting torch and the machine-tool action. The machine was so designed, as previously explained, to give a clean cut and sharp edges to the work when employed on steel of any nature. The blow-pipe is so placed in the construction of the equipment as to give universal movement over the work being done. All parts of the machine are very light in construction, since the machine-tool itself is required to carry no other weight than the cutting arm, on which is mounted the blow-pipe. All parts are carefully fitted with the object of obtaining the smoothest drive possible coupled with freedom from period of "dwell." Anyone familiar with the Oxy-acetylene cutting torch as applied to work which is required to be accurate, can readily understand that even a minute "dwell" will result in defects in the material being cut; the reason for this, of course, is that should the work slow up the dissipation of heat from the flame will not be sufficient, and therefore, there will be a tendency to heat up the work and the oxygen will bite into the sides.

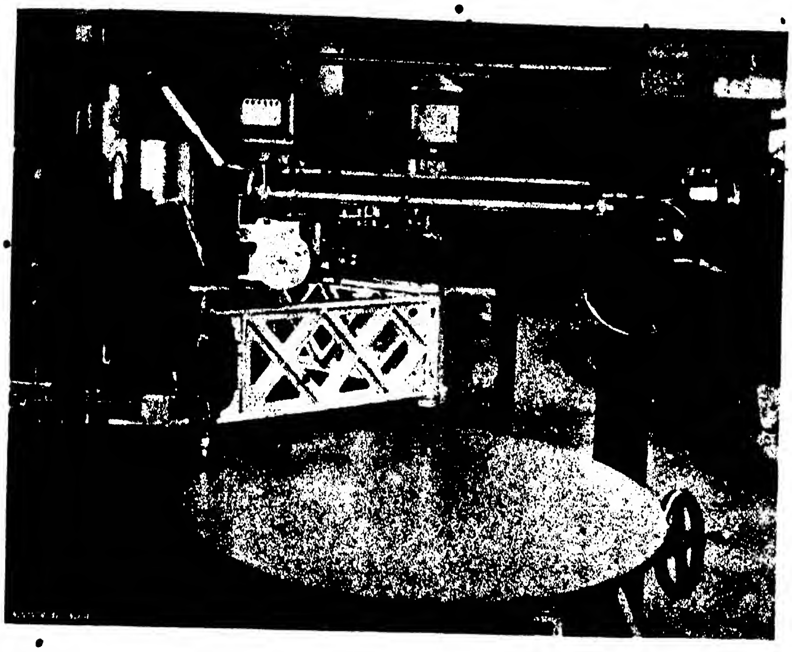
The blow-pipe is mounted on gate supports. Two aluminium arms somewhat deep and at right angles to each other of generous design are employed to support the blow-pipe; this ensures the blow-pipe being kept in a vertical position. The arms are also mounted in such a manner as to leave the slides free from all strain. All joints on the moving parts are fitted with ball bearings. There are two slides. The upper one is carried on a large bearing and is projected from the main frame, allowing for the rotation of the slide to any required angle. The advantages from this, are that it provides for straight cuts parallel with the cross rails of the machine, or inclined diagonally to them.

The second slide is similar to the first one and is supported crosswise on a roller carriage. The movement of this slide is obtained with the smallest possible amount of friction.

A small motor of only ¼ H.P. is required to drive the machine. This has been designing to run at 600 R.P.M. The power is transmitted from the motor by means of a small belt travelling over pulleys to a flexible driving shaft. Illustrations are given herewith from which a general idea of the machine can be obtained. To control the speed of the apparatus two friction boxes are mounted on the machine, one on the right and



Cam 1½" thick by 8½" long by 6" wide Time 6½ minutes



3' 6" disc shown on Rotary Table ¾" thick Time 17 minutes

another on the left, on the upper side or on the cross-head.

Viewing the machine from the front, the friction box at the left is fitted with a hand lever and a small pointer, which when operated is caused to move over the graduated scale indicating the speed obtained; naturally the speed which results from the use of such an apparatus is very sensitive. The two slides are driven from the flexible shafts by means of pinions; the idler pinion is fitted to provide for a reversal of the feed motions when necessary and is controlled by stop bars operated by levers. Three positions are provided for with adjustable stops, the motions being tripped mechanically if so desired.

The second friction box or the one at the right of the cut at the top receives the drive from the first box by means of a cross shaft and two gear boxes. By this means feeds are obtained for either slide over a range varying from ½in. to 20 ins. per minute.

The igniting of the gases is accomplished by means of an ignition jet. Small micrometer valves control the gas mixture and are so arranged that they can be locked, with the result that once the proper mixture has been obtained no alterations can take place unless further adjusted. This is a great advantage in that should the machine stop for any purpose it can be re-started with the same mixture and pressure, no time being lost in re-adjustment.

The machine is automatic in all its cuts; circular, straight or irregular shapes. For irregular shapes all that is required is to cut a template out of thin wood, or other suitable material, and the machine will duplicate it to a great degree of accuracy.

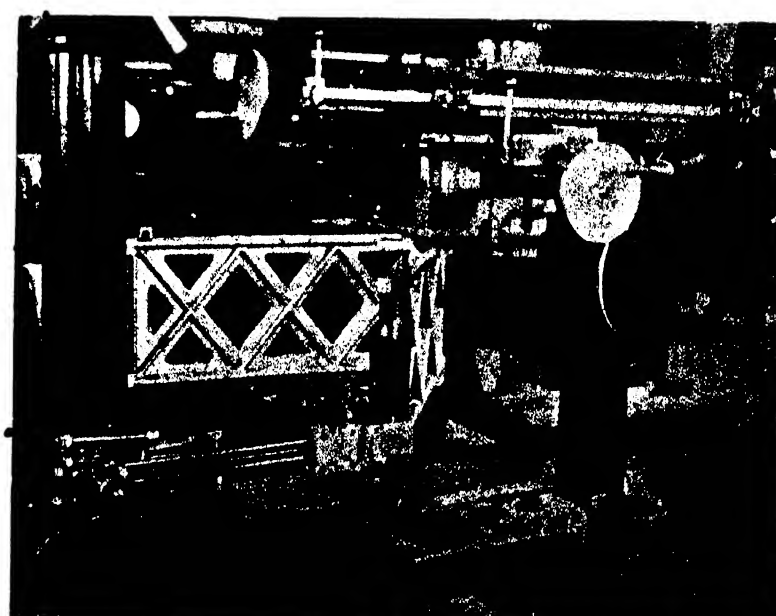
In order to give the reader some idea as to the speed and economy of this machine we quote the following:

The cam blank on the extreme left having a diameter of 11 ins. and a thickness of 1¼ in. required only six minutes to cut the profile at a cost in oxygen of 2¾ pence, no machining being required to finish the job. The surfaces left when using this machine are smooth and have clear cut and sharp edges.

With regard to the horn-plate it took 17½ minutes to cut, the outside edges requiring 11½ minutes and the inside edge six minutes, the total cost of the oxygen being 10d. This plate was cut on the rotary table with the aid of a superimposed template. The piece of work as cut was finished in all respects, no machining being required.

A 5 in. square bar can be cut in one minute and a quarter, that is, at the rate of 20 square inches per minute. A band saw when sharp cuts at the rate of one inch per minute.

A proving apparatus for Brinell hardness testing machines, consists of a steel-yard arrangement which may be attached to the Brinnell machine, and which enables the accuracy of the standard load of 3,000 kilos to be examined. Messrs. Avery are prepared to use their apparatus for testing machines submitted to them.



Boring attachment on upper slide.
Thickness of plate, 2½". Size of hole, 5" Time 5 minutes

The Amplokon Petrol Economiser

THE claims made by various manufacturers of petrol economy devices have often to be accepted with reserve, because, from a theoretical point of view they may be everything to be desired, but when it comes to practice, many devices may not, and in point of fact do not, repay the time spent in fixing and adjustment, to say nothing of the initial outlay on the device.

According to the test reports before us, the "Amplokon" petrol economiser, of which the following is a brief description, has proved itself in practice, and is a *real* economiser deserving the most careful attention of all motorists, and proprietors of motor transport companies in India who desire to effect an appreciable saving in petrol.

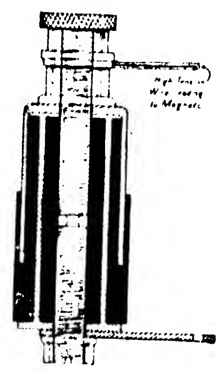
The "Amplokon" which is shown in illustration is essentially for increasing ignition efficiency, and the far-reaching effects of this increased efficiency will be readily appreciated by the following table, which shows the increased mileage per gallon of petrol obtained after fitting the "Amplokon" auxiliary spark gap and condenser.

Vehicle.	Mileage increase per gallon
Old 8 h.p. one cyl Rover...	21%
2¾ h.p. A.J.S. motor cycle	62%
Rolls-Royce	17%
1 h.p. J.E.S. motor cycle...	24%
15.6 h.p. Standard (1912)...	40%
3½-ton Thornycroft ...	25%

Operation of the "Amplokon"

The "Amplokon" consists of two condensers in parallel with a gap, and the whole in series with the sparking plug. It has been designed for the purpose of augmenting and transforming the current from the magneto or coil, and delivering a spark of the highest efficiency and frequency at the plug points. As the gap is only .45 m/m., it is obvious we are working to the capacity of the condensers.

By its means the voltage is increased, and the "spark thrust" is greatly intensified and quickened. The extra force and speed of the "thrust" occurring at the plug points reaches the explosive mixture in the further extremities of the cylinder, resulting in the complete explosion of the vapour, but also firing it more rapidly. It is recognised that the slower the explosion, the greater the loss of power. It is therefore claimed that an "Amplokon" ensures that



the maximum of power is instantaneously available at the right spot and time, which is the ideal long sought by all motor engine designers.

The rapid-complete-explosive-power of the "Amplokon" spark makes it feasible and possible to use a much weaker mixture with an increase of power, easier starting, and more rapid pick up.

Thus the basic advantages of this device become quite clear upon consideration of the following:

It is a well-known fact that a rich mixture is more difficult, and takes longer time to explode, than a weak mixture, and it is therefore claimed that the "Amplokon" makes it possible:

(*a*) To use a weaker, a more easily exploded mixture.
(*b*) To explode the weaker mixture more rapidly and thoroughly.
(*c*) To get a maximum of power from the weak mixture.

No Extra Work on the Magneto

We would here point out that we are assured that this device does not throw any extra work on the magneto, and the following extract from a test report prepared by Maurice Percheron, Consulting Engineer to the French Government, should be of interest to prospective users:—

> "This first series of tests proves in an incontestable fashion that such a disrupter does not throw any more work on a magneto than that for which it was designed."

Another point of considerable interest is that, should the plugs get oiled up, the spark, owing to the action of the "Amplo," is strong enough to jump the gap, and, further, it has been found possible to cut down the sizes of jets and choke tubes without loss of power, thus saving petrol.

Conclusion

This device, which is made by Messrs. Cardwell & Co. Ltd., of 36 Shaftesbury Avenue, London, W.1, is easily fitted, its initial cost is not great, and we can easily believe that the saving in petrol consumption and plug renewal would save its price in a very short time.

A LARGE CREOSOTING PLANT FOR RAILWAY SLEEPERS

Railway engineers are in fairly general agreement that creosoting is the most satisfactory method of preserving timber which has to be used in places where fungi and various insect enemies can easily get at it. It is also recognised that the process, to be really effective, must be carried out in carefully designed plant. There was recently erected and tested before shipment abroad a large British plant, which is capable of creosoting nine hundred sleepers per day of eight hours, these sleepers being large enough for lines with a gauge of one metre. The machine comprises two large receptacles, one above the other, the lower one being the working cylinder, which is thirty six feet long and capable of withstanding a pressure of two hundred pounds per square inch. The top receptacle contains the creosote; and one charge can be completely transferred from this cylinder to the lower in eight minutes. The boiler, which is provided to supply steam for the pumps, is designed to burn wood waste; and the whole of the plant is produced so as to withstand the most severe service.

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS

Electricity in Modern Engineering Works

UNDER the above title an informative paper was read before the Institution of Production Engineers, London, by Mr. J. R. Smith, A.M.I.E.E., and from which we make the following extracts referring to the application of electrical power transmission in modern engineering works.

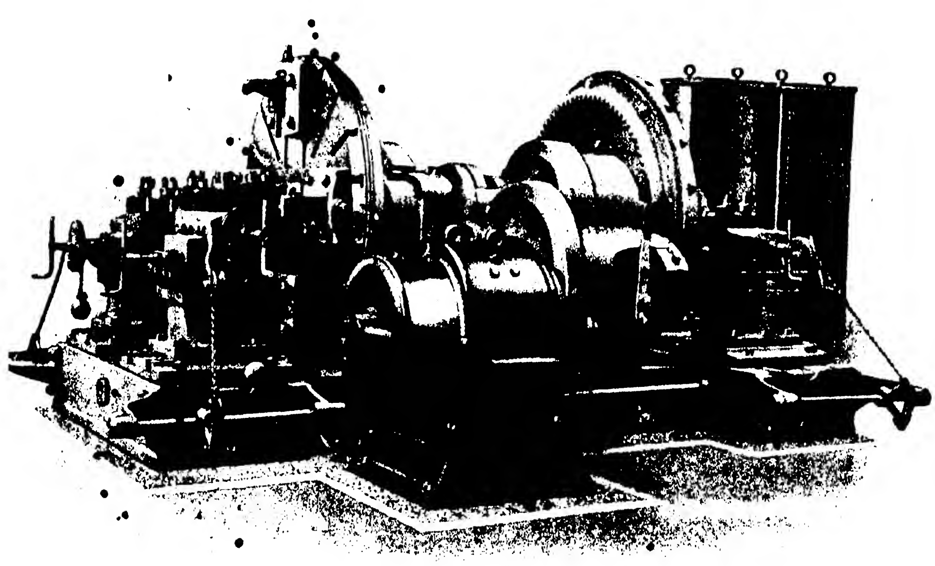
The number of different applications for the electric drive in such works, has increased during recent years in a rather remarkable manner, and Mr. Smith gives some interesting examples of the special qualifications of the electric motor under varying conditions.

Referring to the conditions now obtaining, we find that engineering works may be classified under three groups: first, small works which derive their power from small prime movers situated in or near their sphere of operation, external power from other sources not being available or too costly. For such works the internal combustion engine usually gives economical results, and being simple in construction and operation can be tended by semi-skilled labour.

In the case of larger concerns, however, one usually finds that steam can show good results and is more reliable in operation. Very low working costs may be taken as the rule with the modern high-speed surface condensing units, making it extremely difficult to justify recourse to external supplies, especially if the plant under consideration can show a good load factor.

Secondly, there are larger works running under similar conditions which are able to operate more economically because of the higher efficiency of their prime movers. Then there are works so situated that they can obtain an external source of power at a lower cost than can be generated locally. In each instance the existing conditions will naturally govern the choice of unit for power production, usually based upon the cost of fuel or other controlling factors.

In the third case, there are works—some large, some small—obtaining an external supply of power which is quite justifiable provided that it can be definitely shown that certain beneficial features exist, such as lower costs and economy of space. In such cases, the external sources



Double Tyre Boring Lathe, by Craven Bros. Ltd., driven by two 15-H.P. Metropolitan-Vickers Direct Current Motors

Squirrel Cage Motor Driving Vertical Boring Mill *English Electric Co. Ltd.*

of power can compare favourably, particularly if future extensions are contemplated.

It is of the greatest importance that all the factors in the case be considered when selecting a power supply, as, although figures can be advanced in favour of external power, yet it may be possible to show better results with local units under certain conditions.

Power for Workshops, etc.

The usual method of obtaining power is by means of direct current generators running in conjunction with a suitably arranged switchboard distribution, and, provided that the power house is in a fairly central position, economical working can be maintained.

The choice of voltage is an important factor and one in which much saving in first costs may result. During the last fifteen years the electrification of works has passed through various stages. In the earlier schemes 100 to 120 volts was usually adopted as a working pressure, possibly due to the fact that higher voltage motors were not then sufficiently perfected. Although the 110-volt motor has given good and reliable service, yet the cost of its large copper cables due to the high amperage makes its first cost considerably higher than for systems of higher pressures. Although this disadvantage is obvious, yet it must be remembered that the low-voltage machine usually gives less trouble than the high pressure machine.

For modern practice, however, it is realised that pressures of 230 and 460 are now quite suitable and conform with the general conditions of internal or external sources of supply. The shunt or compound-wound machine at, say, 460 volts is quite reliable and efficient, standing up to its work and being equal to the 110-volt motor in its performance. The question of cable insulation for the higher pressure and the requisite precaution for safe working, of course, become of greater importance, and the maintenance charges are rather higher.

It is an extraordinary fact that one may visit some of the largest works in the country and find 110-volt systems in operation, no doubt owing to gradual developments having been made at this pressure until in the end it has become inexpedient to make a change to the higher voltage.

For works power, shunt, compound, and series wound machines are suitable for all ordinary purposes. For line shafting the shunt-wound motor will usually meet all requirements, since it has a comparatively uniform speed for all loads, is of simple construction, and easy to start. Possessing a good torque, it is employed almost universally for this class of work. There are, however, other considerations to be taken into account in connection with shafting drives. One usually finds a large motor driving long lines of shafting that operate a large number of machines through belting. Although this is a convenient method, yet the question of ultimate costs should not be overlooked, and consideration should be given to the power required to drive the shafting and belts light relative to the useful work performed. A large amount of power may easily be consumed in lost motion. These factors are of importance. When power requirements for shops are put forward, the grouping of machine tools is the first consideration, and, by judicious arrangements, much lost power can be avoided. Large machines that deal with work requiring time for setting up, and absorb, say, 10-h.p., should be provided with individual motors in perference to being driven from line shafting. It is seldom advisable to group shafting to take power above 20-h.p. owing to losses in belt transmission, etc.

Another point deserving of more attention is the position of motors. It appears to be thought in some quarters that once a motor is installed and running it is there for ever and will not require further attention, and, in consequence, can be placed in any inaccessible position.

To maintain an efficient service, motors should be placed in such a position that they may be readily inspected from the ground. They should also be within easy reach of the crane that serves the section they drive. As to power transmitted through belts, much may be said on

this important point. Sufficient attention is seldom paid to this kind of power transmission, with the result that the upkeep of machinery is increased.

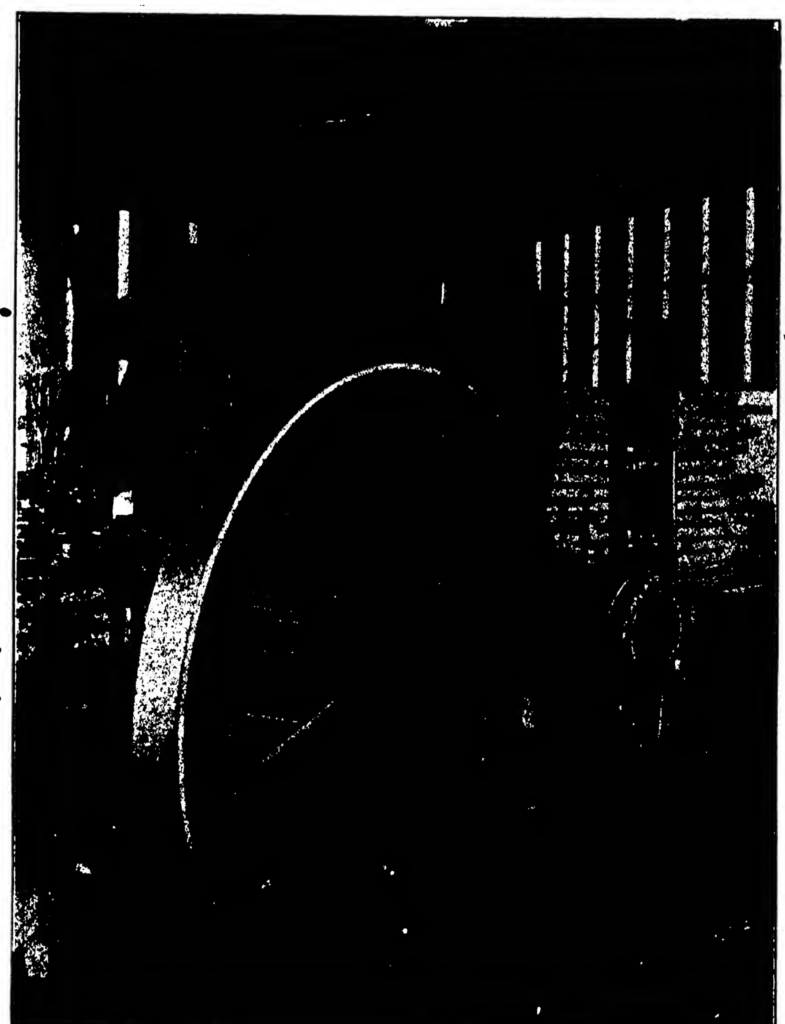
Although well-defined data are available relative to efficient means of belt transmission, this, in many cases, does not enter into the calculation of the official responsible for the layout of the shop. It will usually be found that the widths of pulleys and belts are too small for the load to be transmitted, resulting in great strain and loss of power. The ratios for driver and driven pulleys should also enter into these calculations. It is bad practice to give a greater ratio than 5 to 1 or *vice versa*. It is also inadvisable to raise the belt speed beyond 4,500ft. per minute.

The author has in mind a case where a motor driving high-speed grinding machines running light develops 9 h.p. When the load is applied a further 2½ h.p. is recorded; thus the efficiency of such a drive is extremely small, and it is obvious that the more efficient way would be to drive these high-speed grinders by means of individual high-speed motors.

Another instance of a similar kind was recently brought before the notice of the author. An exhaust fan utilised for removing sawdust and shavings from carpenters' and pattern-makers' shops was driven through a countershaft from line shafting. It was found, however, that the amount of power required from the shafting motor was out of proportion to the fan duty. In addition, this drive gave considerable trouble due to small pieces of wood passing through the fan blades, and the belts could not be kept sufficiently tight. This fan was eventually coupled directly to a motor and current readings taken. It was found that the power absorbed by direct drive was one-third of that taken when the fan was driven from a countershaft. Moreover, since the conversion, this fan has not given trouble of any kind.

Referring to motors for independent machine power, care must be taken in the selection of such machines. The manufacturers of machine tools usually give the maximum power required to drive their particular machine tool, but it is also advisable to consider the nature of the work upon which the machine will be engaged. For instance, in one case the machine may be required for heavy duty, such as roughing out or similar work which will absorb a large amount of power in consequence; but, on the other hand, a machine of this type may be engaged upon a considerable proportion of light work with only an occasional heavy duty job. It will thus be seen that, although in some cases it is advisable to instal a motor of the maximum horsepower, yet since the difference between intermittent heavy duty and much lighter work is proportionately large, it might be advisable to use a smaller motor with, say, a half-hour rating for peak load conditions. It is seldom found that the maximum horsepower as given by the manufacturers can be maintained continuously. As a case in point, a certain high-speed lathe came under the notice of the author. The makers stated that this machine required a 10 h.p. motor to give full duty. Such a machine was provided, and careful readings were taken on heavy work with the maximum speed and feed recommended. It was found, however, that to develop 10 h.p. the belting would not stand up to the work, and the cut proved far too heavy for the machine. Several lathes of similar pattern were eventually installed and driven by motors of 7 h.p.

Another type of motor is often used in connection with machine tools, and is one that can be recommended with confidence. Reference is made to the variable speed shunt machine. With this class of motor, gearing and cone belt drives may be reduced to a minimum, and higher efficiency obtained, and often more accurate work is produced. By the judicious selection of these motors it is possible to increase output by 30 per cent.,



Typical Drive Through Gearing — *Metropolitan-Vickers Electrical Co. Ltd.*

due principally to the flexibility of control.

The application of individual motors to machine tools has played no small part in the rapid development of certain classes, chiefly planing machines, milling machines, high-speed drills, high-speed grinders, etc., but in the view of the author the most modern application is that of the planing machine. By means of variable speed motors it has been possible to increase the number of operations which can be undertaken at one setting, thus effecting a saving in time and power and gaining the advantage of the greater precision which attaches to the machining of work at one setting.

For example, there is a machine of the planer type electrically driven and controlled which planes longitudinally and transversely and slots at one setting. The motors in this instance automatically operate as power or self-act according to the functions to be performed. The operation is under perfect control from the machine attendant's position, long or short strokes being adjusted without stopping the machine. In addition, the speed can be varied on the cut, on the return or between given points. Thus it will be evident that such a machine is far superior to the ordinary belt or motor-driven planing machine. In this connection, it may be stated that in an engineering works in the North of England one planing machine of this type displaced seven ordinary machines and turned out more work in a given time.

A new type of motor has recently been developed for industrial purposes, and it possesses characteristics not found in the shunt-wound motor, namely, constant torque for variable speed. It is a three-phase machine arranged with a variable number of poles, the combination or grouping giving certain fixed speeds, such as 375, 500, 750, 1,000 and 1,500 for fifty cycles. This machine is of the slip ring induction type, and is controlled by means of a tramway type drum. Without resistance of any kind, the machine conforms to requirements for machine tool driving, and, as it possesses slip rings only (that is, no commutator), it should find a place in modern engineering shops.

Squirrel Cage Motor Driving Circular Saw — English Electric Co. Ltd.

As polyphase supply in the future will be the chief medium employed for lowering the cost of power, it is obvious that where alternating current motors can be applied under such conditions they should surpass the direct current unit, provided that a reasonable power factor can be maintained. In the opinion of the author we are on the eve of further development in this direction. Reference is made to the synchronous induction motor operating at unity power factor. Although this type of machine has only recently been placed on the market, it is possible that there will be vast improvements effected in this class of motor.

Very much may be saved in first cost and economy of operation if the problem be studied in detail and all reasonable possibilities taken into consideration. As compared with mechanical means, the flexibility of operation and accuracy of power measurement for costing purposes, electrical power gives results not possible by any other form of energy.

At the present time this country is undergoing a process of reconstruction, and in this period it is hoped that some attempt at effecting a reasonable form of standardisation relative to electrical power will be made. It is regrettable that so great a diversity exists with regard to voltage and periodicity of supply. One finds all sorts of pressures, especially on the direct-current systems, and some absurd periodicities on alternating current systems. If we are to develop along sound lines, this chaotic state of affairs must be abolished and voltages standardised.

As an example: Dover is arranged for several pressures, and 100 cycles; Highgate, 74 cycles; part of the South Metropolitan supply, 25 and 50 cycles; one of the largest power stations in London 33⅓ cycles; and so forth. The American continent and also many European countries have standardised their pressures and frequencies, and there will be general agreement that no useful purpose can be served in maintaining such a varied supply as is now the case in this country.

NEW ROLLING STOCK FOR INDIAN RAILWAYS

If the Ackworth report on Indian railways brought out one fact more definitely than any other, it was that there is a tremendous need for the speedy provision of a large number of additional passenger and freight vehicles on the railways of India. The shortage of rolling stock in all parts of the country has been responsibls for a good deal of "waste," and this is a matter that must be dealt with specially in the development of improved measures. According to recent advices, nearly 7,000 passenger vehicles and over 55,000 freight vehicles are required during the next five years, and it is sincerely to be hoped that nothing will be allowed to stand in the way of the early ordering of those allocated for the years 1922-3-4.

Recent Developments in Power Production

The following abstracts are from Mr. D. L. Selby-Bigge's paper read before the Iron and Steel Institute, London.

AT the annual meeting of the Iron and Steel Institute, London, Mr. D. L. Selby-Bigge, read a paper on the above subject, in which he reviewed the field of power production in a very full and exhaustive manner.

Some of the sections referred to have recently been dealt with in INDUSTRIAL INDIA, notably mechanical stokers, coal washing and pulverised coal, and we therefore do not propose to reproduce these sections in detail, but otherwise propose to give full extracts from Mr. Selby-Bigge's very instructive paper, who commences his subject by dealing with British coals.

It will be realised that the main source of power in England is primarily derived from coal. Coal therefore is the datum line from which we must start in the investigation of the problems of power production. Cheap power is not only an essential factor in industry, but creates a direct incentive to enterprise in every direction, and in those localities where cheap power exists new industries will develop and prosper.

It will be generally conceded that immense quantities of combustible fuel of low grade quality and waste gases remain unutilised throughout the country at the present time, which with modern appliances and treatment can be economically converted into steam, or other assets of the greatest value.

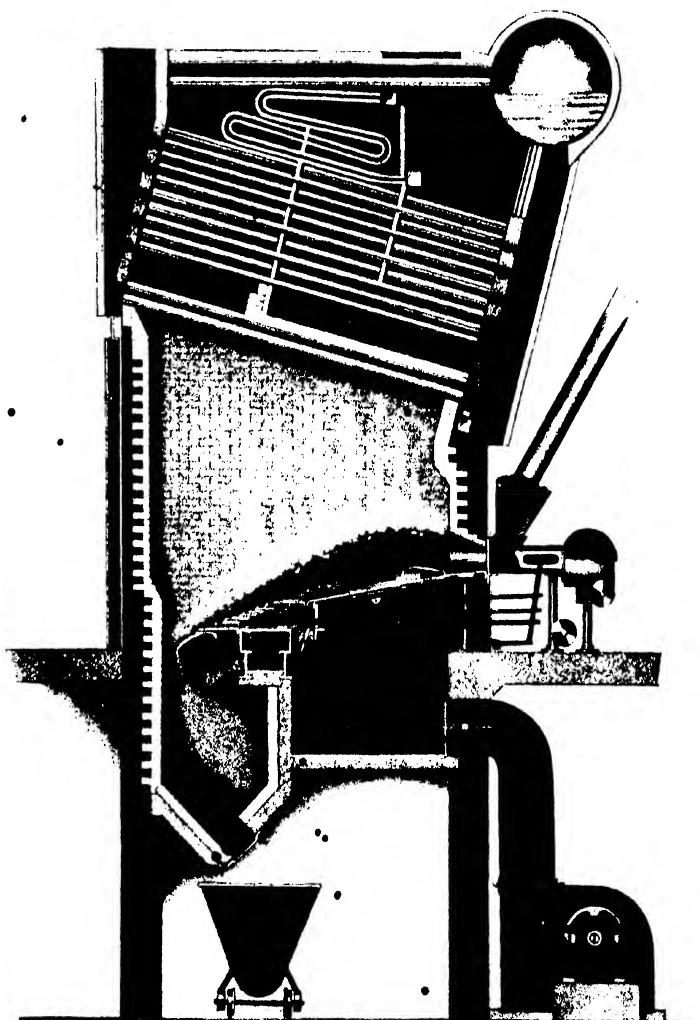
The scientific treatment of fuel amongst the industrial plants and collieries in this country has not, until recently, received anything like the attention that it merits.

Of late, however, a distinct tendency has become apparent to investigate much more closely the economics of power production. The present methods in the generation and transmission of electric power have reached such a high standard, both as regards steam turbine practice and efficiency in electrical generators and motors, that one cannot look to anything more than comparatively trifling economies in the engine room or power station.

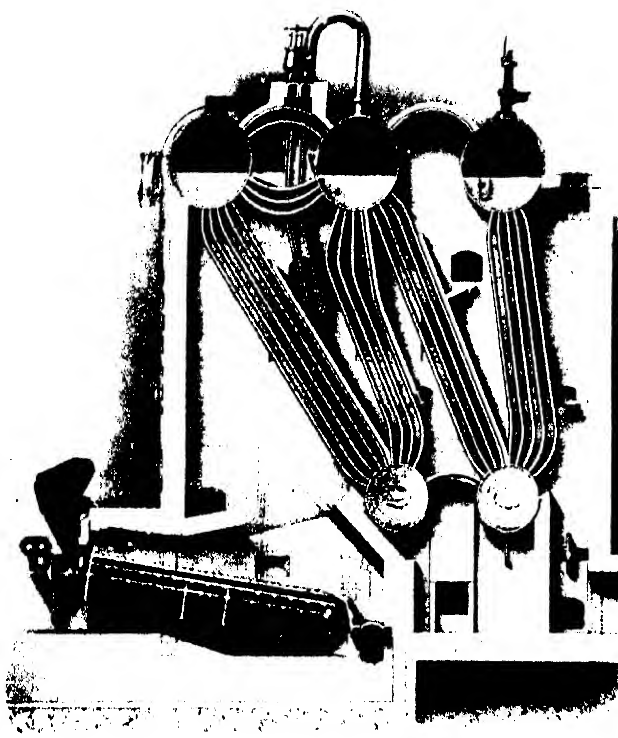
It is towards the boiler houses and the efficient use of the various grades of fuel available in the country for steam raising that one must turn when looking for savings, and where an immense field and ample scope for economy will be found.

This, however, is not the only source from which cheap power can be derived, and consideration will be given at a later stage in this paper to the utilisation of waste assets, in the form of blast furnace gas, coke oven gas, and gas from re-heating and regenerative furnaces as applied to the raising of steam for power production purposes.

There is one very important point in connection with steam raising in industrial plants, which the author would particularly like to emphasise, and that is the need for skilled supervision and control in the boiler house. It may be taken as a general



Erith Retort Stoker



Stirling Boiler; Stoker for Burning Low Grade Fuel

rule throughout the majority of the collieries and works in this country, that the boiler staff employed is not of such high standard either technically, or scientifically as the staffs usually employed in the engine-room.

Coal Consumption

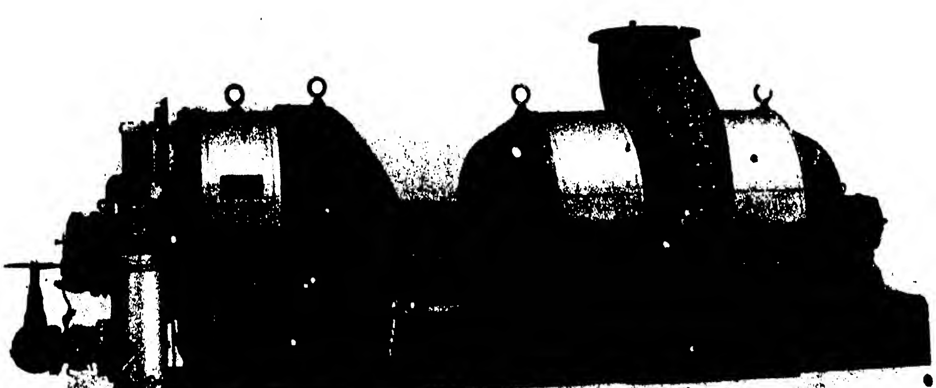
In a detailed investigation of twenty four collieries in various parts of the country, instituted by the Board of Trade Coal Mines Department in 1918, it was found that the consumption of coal varied from 4.5 per cent. to 16.5 per cent. of the total production, showing that a very wide variation exists in the economy obtained by various plants. It is well known that while in certain districts notably South Wales very special attention is being paid to the question of coal economy, there are still a very large number of cases among the three thousand odd collieries of the country, where little or no attention has hitherto been given to the question.

During the period of coal control, when the shortage of all classes of coal, due to war conditions, made it imperative to tap every available source, some most interesting researches were conducted by the Coal Mines Department. Amongst these was the possibility of utilising "pit heaps," many of which had been standing for as long as forty or fifty years, and in a paper read by Mr. David Wilson, before the Association of Mining Electrical Engineers and Colliery Managers at Glasgow in 1918, very comprehensive analysis of these fuels were given. Table I. is an extract of some of the more notable instances of low-grade fuels, available from such sources.

It was calculated that at that time there were some three million tons of so-called refuse coal lying at the pit heads, and estimated to be of an average calorific value of 5,000 B.Th.U's.

Naturally, a great deal of this fuel, as indicated in the Table I, was particularly high in ash, some of it containing even 50 and 60 per cent. Subsequent events, however, proved that a very large proportion of this fuel could be used for steam raising purposes.

In the Report issued by the Electricity Commission, in January of this year, the following interesting statistics appear, taken from public supply stations, consuming coal or coke:



Steam Turbine and Turbo-Blower

Fraser & Chalmers, Ltd.

Table I.

Description of Sample.	Percentage Ash.	Percentage Moisture.	Calorific Value B.Th.U's.
Yorkshire Settling-bed Fuel	10.51	16.16	10,240
Derbyshire Slurry	19.08	25.85	7,166
Staffordshire Washer Refuse	54.53	6.68	3,825
Lancashire Washery Dirt	39.47	1.75	8,073
Yorkshire Waste from Washery Drainage ...	16.43	19.07	9,171
Yorkshire Dirt from Washer	66.48	4.62	4,473
Leicester Settlings from Washer	34.69	27.39	4,673
Yorkshire Shale	49.38	2.65	6,931
Staffordshire Brick-kiln Pit Tip	34.68	8.25	7,808
Staffordshire Bats	49.98	7.43	5,484
Shropshire Shale	67.65	2.35	3,883
Staffordshire Smudge	34.33	26.10	4,525
Staffordshire Grass-grown Heap	18.71	9.17	9,306
Staffordshire Waste Material	37.35	2.34	8,087
Warwickshire Bats	25.89	7.61	8,689
Warwickshire Shale Coal	37.03	12.82	6,413
Staffordshire Pit Mould	35.42	10.54	6,429
Derbyshire Waste Heaps	28.53	11.53	7,409
Leicester Refuse	47.02	6.03	4,948

No. of stations	403
Total units generated ...	4,965,514,403
Total coal and coke consumed	7,356,757
Average coal consumption. lbs. per unit generated ...	3.32
Lowest coal consumption at any station, lbs. per unit generated	1.70
Highest thermal efficiency for any station (approximate), per cent. ...	17.75

The Cleaning of Coal

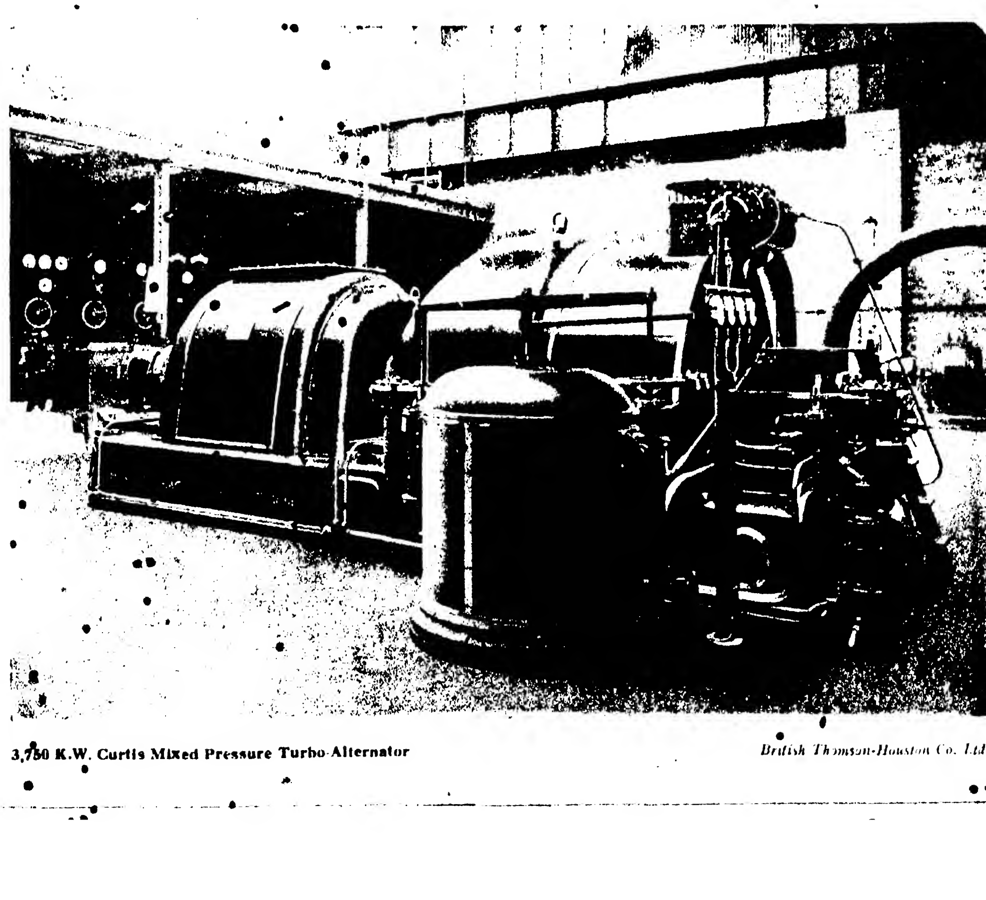
In connection with the use of coal for power production it is interesting to note the development of the Froth Flotation Processes for cleaning fine coals.

It is impossible within the limits of this paper adequately to describe either the principles underlying the process, or in detail the method of application. The salient features are, however, that coal or coal-bearing waste crushed to pass a screen of about one tenth inch linear aperture is treated in the form of pulp consisting of approximately four parts of water to one part of coal.

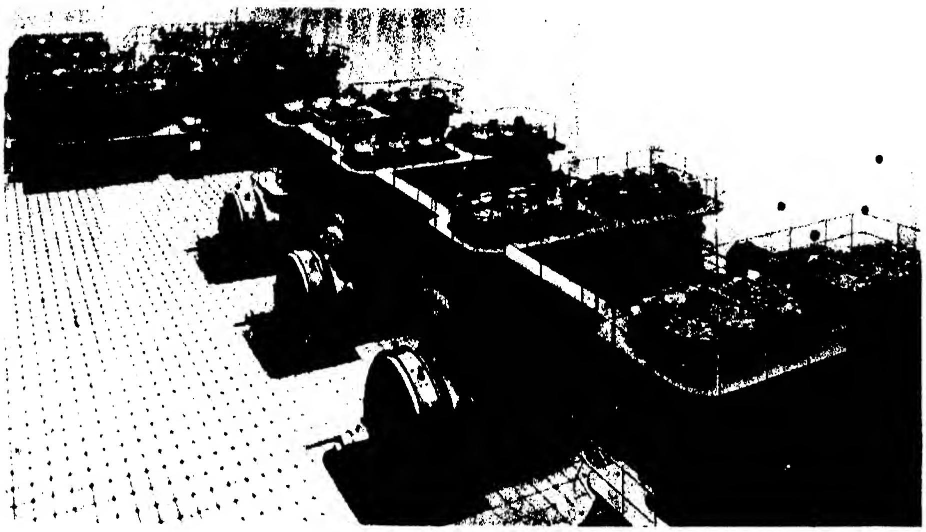
The author understands that several units having capacities of 40 tons hourly are now in course of erection, and that for a plant of this size the average cost of cleaning the coal, inclusive of power and labour, but exclusive of interest and depreciation, amounts to 4d. per ton treated.

The potentialities of these processes are therefore of importance; they open up the possibility of bringing to the surface and converting to industrial use the fine and low-grade coals of which considerable quantities are now left underground, while the grade of the coal treated is raised and its efficiency enhanced.

These processes constitute an advance in the conservation and utilisation of fuels, and are worthy of the attention of those who are concerned with the production of power.



3,750 K.W. Curtis Mixed Pressure Turbo-Alternator — *British Thomson-Houston Co. Ltd.*



Vertical Gas Engines (10,000 H.P.) Working on Blast Furnace Gas *National Gas Engine Co. Ltd.*

Water-Tube Boilers

Size of Units. Water tube boilers have been installed capable of evaporating 130,000 lbs. per hour normally, and this duty has been increased on overload. The author has been informed that in the case of the Ladd boilers at the River Rouge Works, of the Ford Motor Co., at Detroit, 276,000 lbs. of water per hour were evaporated from one of these boilers for fifteen hours, and for two hours 327,000 lbs. of water from one boiler per hour. This is a wonderful advance, considering that thirty years ago, the maximum steaming capacity of a boiler was 7,500 lbs. per hour. There appears to be no difficulty in constructing very large boilers, the limiting factor being confined more to furnace design, but with industrial plants 30,000 lbs. evaporative capacity will be found a convenient size of unit to adopt.

Pressures. Pressures during the last few years have increased considerably ; 250 lbs. pressure is quite common, and several boilers are working at 350 lbs. pressure. One large new modern boiler house is being operated at a daily working pressure of 475 lbs. per square inch. The ultimate economy to be obtained from high pressure is not yet definitely established, but if turbine design calls for even higher pressure, it would appear that the above boiler pressures can be still further increased so far as the makers are concerned.

Superheaters. Integral superheaters can now be fitted to boilers to give a final steam temperature of 650 deg. to 750 deg. F., and this maximum is not likely to be exceeded as it is approaching the limiting temperature of the steel tubes.

Stokers. The stokers employed are mechanical, the chief makes being the chain grate stoker, with both natural and forced draught, the underfeed stoker, the sprinkler and coking stokers, and the multiple retort stoker.

Production of Power from Waste Gases

(*A*) *Blast-furnace Gases.* In general, the blast-furnace gases available in England are uncleaned, and when using such gas for firing boilers (more especially of the water-tube type), an external chamber is provided which, although it does not give such a good intermixture of air and gas as a Bunsen type burner, has the advantage of not becoming clogged up with dust.

With the advent in iron and steel works of gas-cleaning apparatus, the tendency is now to fit boilers with Bunsen, or multiple-type burners, and whereas with the combustion chamber the efficiency under normal working conditions is probably not more than 63 to 65 per cent., for boiler and economiser, with clean gas and burners the efficiency can be raised, and 73 to 75 per cent. obtained, which would mean that approximately for each lb. of actual steam evaporated, there would be required 16 cubic feet of gas at 100 B.Th.U's per cubic foot.

The following are particulars of a test using blast-furnace gas in conjunction with a Harrison furnace :

Heating surface of boiler	3082 sq. ft.
Grate area ...	43 sq. ft.
Temperature of waste gases entering furnace	1892 deg. F.
Working pressure ...	130 lbs. per sq. in.
Draught at boiler damper	6.4 inch.
Water evaporated per hour from and at 212 deg. F.	12,495 lbs.

(*B*) *Coke-oven Gases.* There is a considerable field for the utilisation of surplus heat from coke-ovens and from the ordinary by-product coke-oven plant. It can be taken as a general average that 80 per cent. of the gas will be available in the form of waste heat, at a temperature of 1,800 deg. to 2,000 deg. F., and 20 per cent. in the form of surplus live gas having a calorific value of 450 to 500 B.Th.U's.

The evaporation obtainable from the combination of waste heat and surplus live gas is approximately 1¼ tons of water, from and at 212 deg. F. per ton of coal carbonised. This surplus gas is generally burnt in

connection with Bunsen type burners, and efficiencies for boiler combined with economiser have been obtained as high as 80 per cent. Under normal working conditions, an efficiency of 70 per cent. can be relied upon for boiler alone.

The following is a good example of figures obtained on test :

Total gas supplied per hour	208,875 cu. ft.
Calorific value (lower)	428 B.Th.U's.
Evaporation (actual) ...	58,060 lbs.
Working pressure ...	196 lbs.
Feed temperature ...	86 deg. F.
Superheat	158·60 deg. F.
Cubic feet of gas per lb of water evaporated	3·58
Boiler efficiency ...	74·2 per cent.
Efficiency of boiler combined with economiser	80·2 per cent.

In connection with coke ovens where live or illuminating gas is available, this can be consumed under the boilers through the ordinary standard burner, either of the "Terbeck" or "Harper" type. The following information will give particulars of a test run under such conditions :

Heating surface of boiler	6,000 sq. ft.
Working pressure per sq. inch	185 lbs.
Superheat	150 deg. F.
Temperature of feed water entering boiler ...	130 deg. F.
Temperature of exit gases from boiler	466 deg. F.
Gas pressure at boiler header	2.75 inches.
Gas pressure at boiler side of governor ...	3.1 inches.
Number of burners, type "Terbeck"	13 per boiler.
Evaporation per hour from and at 212 deg. F.	33,540 lbs.
Efficiency, approximately	85 per cent.

Where waste heat is available from coke-ovens, this would be utilised in the same way as that from a Siemens furnace, or a soaking-pit plant, excepting that the requisite draught would be furnished by means of an ordinary chimney. Particulars of a test on such an installation are given below :

Heating surface of boiler	4170 sq. ft.
Working pressure ...	157 lbs.
Superheat	106 deg. F.
Temperature of gases entering the furnace	2228 deg. F.
Temperature of gases leaving boiler ...	500 deg. F.
Evaporation per hour from and at 212 deg. F.	16,280
Evaporation per lb. of coal carbonised from and at 212 deg. F. ...	1968

(*C*) *Gases from Reheating Furnaces.* There is a great scope for the utilisation of waste heat from reheating, puddling, and other furnaces where the burned gases available are at temperatures of 1,800 deg. F. to 2,000 deg. F. The evaporation obtainable with a well-designed boiler is 5½ to 6 lbs. from and at 212 deg. F. per lb. of coal burnt on the furnace, with gases at 2,000 deg. F.

It has been stated in the case of one firm, where a water-tube boiler was installed for utilising the waste heat from two hoop mill furnaces consuming about 10 cwts. of coal per hour, that they have been able to save approximately 42 tons of coal per week.

(*D*) *Gases from Regenerating Furnaces.* In the case of furnaces of this type, the gases available are in the neighbourhood of 1,000 deg. to 1,150 deg. F., and although the introduction of a boiler in connection with reheating furnaces does not materially effect the draught conditions, a different case arises with regenerative furnaces, as the draught requirements are generally about 1 inch. W.G. This difficulty is, however, overcome by installing a boiler (or boiler and economiser) combined with induced draught fan, the fan giving the necessary suction to make up for the loss in draught through the boiler, and giving 1 inch. W.G. at the boiler inlet.

There are many cases of installation where the fans are so arranged that a draught of 1½ to 2 inches W.G. can be given at the boiler inlet. By the installation of a fan the variations due to atmospheric conditions are eliminated, and it is almost certain that the steady conditions obtained when a waste-heat boiler and fan are provided improve the output of the furnace.

The evaporations obtainable from the waste heat of regenerative furnaces can be taken as follows :

Top Section of Filter Box, "Halberg-Beth" Gas Clearing Plant

General Electric Co. Ltd.

Entering temperature
1100 deg. F. 3.26 | lbs. of water from and at 212 deg. F. per lb. coal burnt on the producers.
1000 deg. F. 2.76
900 deg. F. 2.27

As a general rule, the coal consumption on the producers is 5½ to 6 cwts. per ton of steel produced, so that, on a fair computation, it may be said that an average evaporation of about 2,000 to 2,200 lbs. from and at 212 deg. F. can be obtained per ton of steel with gases entering at 1,100 deg. F.

Pulverised Fuel

The subject of pulverised fuel has been before the engineering profession for a considerable period, and is a question which undoubtedly is worthy of further research and considerable attention at the present time.

The number of applications of this system is not yet very numerous in England, in fact, far greater attention has been given to the subject in the United States of America and on the Continent.

Some two years ago, in the United States of America, approximately 11,000,000 tons of coal were used per annum in the powdered form. Since this date this amount has been much increased, particularly with regard to the generation of power, and in the iron and steel industries.

The 11,000,000 tons can be subdivided as follows:

Six million tons for the manufacture of Portland cement.

Three million tons in the iron and steel industry.

One million five hundred thousand tons for the generation of power.

Five hundred thousand tons in the copper industry.

Some of the most important installations in the United States of powdered coal for the firing of steam boilers are as follows:

The Milwaukee Electric Railway and Light Company, Milwaukee.

The Missouri, Kansas, and Texas Railway, Parsons, Kansas.

The Puget Sound Traction, Light and Power Company, Seattle.

The River Rouge Plant of the Ford Motor Car. Co., at Detroit.

In France the adoption of powdered coal firing, both for the generation of power and in the iron and steel industries, has been very rapid, and whilst installations only commenced to go forward towards the end of 1918, there are now more than 200 turbo-pulverisers alone in successful operation.

The pulverised coal system for steam generation at the plant of the Puget Sound Power and Light Company, consists of the boilers, with a total heating surface of 41,000 sq. ft., together with a complete drying and pulverising plant.

The combustion volumes of the furnaces per sq. ft. of heating were 0.2 cub. ft. under four 3,000 sq. ft. boilers and three 4,000 sq. ft. boilers; 0.3 cub. ft. under one 5,000 sq. ft. boiler, and one 6,000 sq. ft. boiler; and 0.45 cub. ft. under one 6,000 sq. ft. boiler. The drying and pulverising plant contains two driers, indirectly fired by pulverised coal, and dust is removed by means of a fan and a washer, the sprays of which are supplied with salt water from Puget Sound. The coal used is a purely refuse material accumulated at the mine during the last twenty years, and is very fine, practically all of it passing through a 20-mesh screen. The heating value averaged 9,300 B.Th.U.'s, and it is stated that about 190,000 tons of this coal have been burned with an average boiler efficiency of 80 per cent., individual tests showing 77 to 81 per cent. At the same time very high evaporation was obtained, and altogether the results appear to be remarkable.

Another instance in America is the powdered coal installation at the boiler plant of the Missouri, Kansas, and Texas Railway, at Parsons, Kan. This plant was converted in 1916, and consists of eight water-tube boilers, each having 2,500 sq. ft. of heating surface, and was so arranged that oil, natural gas, or pulverised coal could be burnt at will. The experience obtained on this plant is said to be strongly in favour of pulverised coal, and the advantages are given as follows: (1) Maximum flexibility and reliability; (2) repairs only trifling; (3) correctly designed furnaces are easily maintained at high ratings; (4) low grades of coal can be burned with success.

Successful pulverised fuel installations upon a very considerable scale are working at the new Lakeside Generating Station of the Milwaukee Electric Railway and Light Co., and at the comparatively new River Rouge Boiler Plant of the Ford Motor Car Works, at Detroit.

As to the former, pulverised fuel was fitted to the old boilers of the old Electric Station. The installation could not be said to be perfectly successful, yet the engineer of the plant was so satisfied that, with properly set boilers, pulverised fuel would be successful, that he installed such a plant in his new Generating Station at Lakeside.

The boilers at Lakeside are what may be described as the Babcock and Wilcox Land type, but they were made by the Edge Moor Boiler Company. The rate of these boilers is described as being 1,308 horse-power normal, boiler horse-power in America being taken as 34½ lbs. of water per square foot of heating surface.

The system employed is known as the "Lopulco" system.

A series of trials were carried out under the auspices of the American Government at the Lakeside Generating Station, and the amount of data taken probably exceeds that of any other trial. The shortest trial was approximately of twenty hours' duration, and the longest just over forty-two hours, and the efficiencies, economisers included, were from 86.3 per cent. (the lowest), up to 89.1 per cent. efficiency being obtained with a coal of 11,491 B.Th.U's.

Very shortly, reports will be published showing the overall efficiency of this station, that is, the kilowatts generated for coal consumed, and it is the expectation that these will show a remarkable performance.

At the Ford installation the boilers, which are without economisers, and are four in number, have each 26,400 sq. ft. of heating surface. No efficiency trial has been carried out on these boilers, owing to the difficulties involved in arranging suitable water and coal measuring apparatus on the large scale that would be necessary, but the boilers are fitted with numerous instruments which enable the performance to be judged very closely.

The author has been informed that 276,000 lbs. of water per hour were evaporated from one of these boilers for fifteen hours, and for two hours 327,000 lbs. of water from one boiler per hour.

These boilers are probably the largest boilers ever installed.

At the maximum the evaporation was just under 12½ lbs. of water per square foot of heating surface.

The Ford plant has now been in operation for just about a year, and the author understands that the engineers of the plant express their perfect satisfaction with the pulverised fuel equipment.

(To be continued.)

ORGANISATION

Conducted by HARTLAND SEYMOUR

THIS SECTION DEALS WITH WORKS MANAGEMENT AND ORGANISATION, THE TRAINING AND WELFARE OF THE WORKERS, AND WITH THE ADVERTISING, SELLING AND MARKETING OF GOODS

Purchasing

(Abstract of Paper read before the Institute of Industrial Administration, March 14th, 1922)

BY H. M. SURTEES TUCKWELL, M.I.MECH.E.

Buying is just as important as selling in Modern Business, and this article explains the principles underlying the securing of goods of the highest possible value in quality and quantity at the lowest price.

PURCHASING may be regarded as a fundamental element in all business, and may be defined as obtaining the highest possible value of goods in quality or quantity for the lowest price.

To realise such a condition, it is necessary that a comprehensive yet simple routine should be in force, and that the department be directed by one possessing a wide experience and knowledge, coupled with energy and initiative.

This department has in the past received too little attention as a scientific function. One finds much literature devoted to production and salesmanship and a very little to purchasing.

Right buying has a vital influence on the cost of production. We may go farther and say that the success or failure of a business may be attributable to good or bad buying, for it is a fact that a large percentage of the profits of every business depends upon the ability of the purchasing department to obtain the best quality at the lowest price.

A quotation is made for a certain contract based upon estimates prepared and covering direct labour, materials, establishment charges and expected profits. The success or failure to secure necessary raw materials within the price limits of the estimate, lack of promptness in passing invoices and securing best cash discounts, slackness in following up delivery of materials and in the case of shipments, possibly incurring demurrage charges, may contribute towards the elimination of any profits.

It is obviously of vital importance to a manufacturing concern to have sufficient stock on hand, but not a surplus of obsolete material.

In some cases it is easy to forecast a consumption over a period, while in others demands are more uncertain and fluctuating.

The Purchasing Agent

It has been long recognised in America that this is a position of distinction and importance, and in many companies the purchasing agent is a vice-president or a director.

He should be endowed with good common sense and wide technical experience, both of the articles themselves which he has to obtain, their various uses, the methods employed in their manufacture, and possible forms of adulteration or substitute.

It may be thought that this is a counsel of perfection quite unattainable.

Of course, he must realise his limitations. A man who poses as an expert in all the materials he buys soon becomes ridiculous. In these days of increasing specialisation he can at most have intimate knowledge of two or three branches, but he can always call in expert assistance when necessary.

He should be also a keen student of local and national markets.

Consideration of this aspect of the purchasing agent activities has made great progress in this country, and carefully selected, highly-trained officials appointed in most important works.

In the past these duties were often delegated to some individual whose faculty for interviewing travellers and a superficial familiarity with the materials purchased enabled him to discharge the functions of this office without serious comment.

Every busy man will admit the annoyance he feels when a representative's card is thrust before him in the middle of a conference, or when dictating letters, and in many cases this has led to the appointment of a fixed hour, and often a day, for seeing travellers.

Again, in the past many of the representatives soliciting orders for manufacturers were but insufficiently masters of the trade whose products they offered, and were often imcompetent to discuss essential details with their clients.

The writer noted during a six months' visit to the United States, that the majority of salesmen he encountered were graduates of a University, and had specialised in the particular branch they represented and could discuss design, costs, method of manufacture and essential details. The desirability of this need not be emphasised, and our claim that the purchasing agent should be a trained engineer may be extended to the salesman.

As the purchase of materials for a large engineering, ship-building, or steel works company, will involve many hundreds of articles differing in character, material and ultimate use, it is obvious that the purchasing agent holds a position of serious responsibilty. Upon him lies the responsibility for the orders placed, the onus of securing right materials and the right prices, even if as in some establishments the formal orders are signed by the secretary or other official of the company.

The purchasing agent should keep intimately in touch with all other departments; drawing office, works manager, foreman, and specially, storekeeper. Close co-operation between these all makes for higher efficiency in the purchasing department.

It is equally desirable that he should confer occasionally with the

individuals from whom he receives his requistions and indents, and discuss matters arising in connection with purchasing.

This is difficult when the purchasing office is in London, or the provinces, and the works are abroad, but it is then even more desirable for occasional visits by the purchasing agent to the works, or the requisitioner to the purchasing office.

Specifications

Specifications should be clearly and definitely drawn up to ensure that all bidders are meeting on the same plane. In it may be laid down as a first essential that all enquiries should be accompanied by a definite and explicit specification.

The Author remembers receiving a cable some years ago which read: "Ship promptly one gross 1 in. valves." Blue prints and drawings are, of course, a necessary accompaniment to many orders, but it should be emphasised that the enquiry must be presented with such full and complete information, that every bidder intelligently can understand it, for a loosely-worded enquiry to several bidders will result in several quotations which are not comparable.

Generally speaking the purchasing agent is within easy distance of the stores, where materials are warehoused till required, and also directly in touch with departments from whence requisitions for materials have been issued. In such cases he readily may satisfy himself of their exact requirements before issuing enquiries to the makers, and can also refer any matter needing settlement to the same sources. But in other cases the purchasing is undertaken at a head office, remote from the works, and yet again many colonial and continental establishments have an agent in London, or the provinces, and indents are mailed to such agents for purchase and shipment. In such cases a comprehensive specification is a vital necessity.

The British Engineering Standards Specifications are now universally adopted, and it is hoped that the field which they cover may be extended considerably in the near future. In many cases it is advisable to have a complete range of samples of the smaller articles which form a standard basis for obtaining materials.

Agreed standardisation by different departments using the same articles, will enable larger contracts to be placed for individual articles, with corresponding economy in purchase, storage space, and storekeeper's time.

Another opportunity for economy may be found in the purchase of materials with constantly fluctuating values, as for example copper, tin, spelter.

Careful study of sources, conditions of foreign markets, and world transactions are needed, and so many of these materials form a subject of speculation by small brokers all over the country, that it is desirable to have ample notice of requirements so as to choose a favourable opportunity to buy.

It may be often found economical to use substitutes, and the purchasing agent should study the suitability of goods which, while fulfilling the specification in most respects, may offer inducements in regard to lower price, which will justify departure in small particulars.

In addition to the specification required for issuing general enquiries for maintenance supplies, a special specification may be needed in the case of large machines or plant.

At the risk of being criticised for going into elementary details, it may be mentioned that the general specification should cover details of plant, such as lubrication, guarding of gears, demand that full detailed drawings be supplied (a condition which many of our old-fashioned makers contest); stipulate that the vendor indemnifies the purchaser against any infringement of patents, or licences, strikes, and prohibit publicity in respect of publication of details of any order.

Apart from specifying the actual quality of the materials composing the finished article, sometimes it may be necessary to specify the methods of manufacture, and finally certain tests to which the material must be subjected.

An example is Foundry Pig Iron, which at one time was graded by its fracture; now it is usually guaranteed that different numbers will, with a small pre-arranged variation, have a content of certain per cent. of S.Si. P.C., etc.

Another is Electric Cable for which methods of manufacture and tests during and after manufacture are laid down. In large works, the P.A. has the assistance of the Chemical Laboratory and the Physical Test House, in the absence of which he must frequently draw his own samples and have them tested.

On the order form it is good practice to embody the essential details with a heading "Terms and conditions under which orders are placed." If an acknowledgement form is printed at the foot of the order and perforated so as to be torn off and signed by the supplier, it will constitute an acceptance of such conditions.

Inspection

Inspection by the purchaser is generally desirable; while a clause should be inserted in the order form, that the purchaser's inspection does not relieve the supplier of any responsibilty, and a further clause should provide for a guarantee in respect of replacement of defective material or workmanship.

The periodical visits of the purchasing agent or his inspectors form a series of reports of the advance towards completion of a large machine, or plant order, and complete the story of each order.

These reports are also a valuable index of the capacity and reliability of the suppliers; they should contain brief notes of the firm visited—important members of staff interviewed —size and description of works and various departments, *e.g.*, if they have their own foundry, laboratory, testing plant; if methods are good and up-to-date, plant modern, number of men employed, proximity to railways, reliability of sources of supply; if prices consistent and arrived at by scientific methods. They should also note name and addresses of firms, whose works are passed in their travels, with goods manufactured, such data being recorded on the mailing list. The Inspectors will spend a proportion of their time in the purchasing office checking orders placed, and preparing notes to assist them in inspection tours.

They will urge delivery of materials on order and inspect those ready for shipment, material destined for abroad receiving special attention and care, this inspection being extended to packing, to ensure strong, securely fastened cases and ample provision against the action of sea, air and water.

The Inspector should be a responsible person in whom complete confidence can be placed. He should be able to use his judgment and decide matters of policy arising out of his visits. If he is allowed a little latitude in his interpretation of the specification, and judiciously can stretch a point now and again, material and time may be economised. Most works managers are aware of the hard and fast adherence by inspectors to the wording of government and railway specifications, which often result in rejection and destruc-

tion of material, which might be safely employed. On the other hand the latitude suggested must not be too wide, and only judiciously given effect to.

On Choosing a Supplier

While the purchasing agent should always be alive to possible new sources of supply he rightly may determine some one or two firms whose services in the past has justified his reliance on good material and workmanship, and prompt execution of promises.

In this connection it is well for him to study the methods of the firms he deals with, and a personal acquaintance with their works and staff is an advantage.

Having satisfied himself that their methods are irreproachable, their costs accurate and unburdened with heavy overhead charges, due to slovenly methods, or incompetent management, he can place repeat orders with a sense of security that he is being fairly treated.

The personal relationships thus established are a great asset to him, and at the same time keep him informed of the state of markets, capacity of his suppliers, and their manufacturing methods, all these points going to form the data required when placing orders.

While the personal element is of great value in the initial stages of a transaction, it is occasionally an objection in the final settlement.

Assuming a clearly-defined call for quotations to a clear and exactly-worded specification, the purchasing agent should be able to compare his bids, and decide which is the best value for the lowest price. To be harassed by importunate travellers anxious to secure an order is probably the experience of all buyers.

Representatives have said to the Author: "We can quote you a lower price if that is what you want." *Price* must be considered in conjunction with *quality*. It may suffice sometimes to call for a sample with quotation, and it is then for the purchaser to decide, if he is capable, which offer is the best value for money.

The holding of Dutch Auctions is a practice to be avoided most rigorously.

If a firm have made an honest quotation, based on accurate costs, let them abide by it and not bombard the purchasing agent with offers to try and improve on their bids, if they have an inkling that a competitor is a shade lower.

Healthy competition is a stimulant to Industry, and should not be abused. Quotations should be regarded as strictly private and confidential.

Records

Records may be classified in two divisions :—

(1) Orders and requisitions.
(2) Data and general information.

In the first connection the following records are involved :—

- Requisition or indent received.
- Specification and all essential data collected.
- Enquiry made out and issued.
- Quotations received and compared.
- Selection of the best material.
- Order drafted and typed.
- Figures and conditions checked before being sent out to purchasing agent for signature and transmission to the selected supplier
- Correspondence regarding details, shipment, inspection, etc.
- Inspector's reports received and filed.
- Invoices received.
- Invoice paid and discount obtained.
- Receipts received.
- Whole order shipped.

The File is then *Dead* and may be transferred to the *Dead Cabinet*.

"Rush Orders" should be avoided as far as possible. They are bound to upset the *Routine* of the department, and are not conducive to economical purchasing.

It will be noted that the file when closed is a complete life history of the subject.

2. *Data and information.* This second classification is never dead, but always must be clearly recorded, readily accessible and kept up to date.

Some of this data is recorded from actual transactions carried out by the department, while other necessary data must be collected from outside sources, or other departments of the works, technical journals, extracts from correspondence, metal and other raw material bulletins. This data is more essential to the purchasing department than any other.

It is advisable to have card index records of all purchase, one side bearing the record of the order, while the reverse side contains a list of suppliers of the particular goods, and then forms a mailing list.

The cards can be ruled with spaces for recording particulars of the firm's capacity and ability, their promptness in executing orders, and a private code may be utilised to signify the order in which their value is assessed. In will be appreciated that this data is constantly changing, and the mailing list needs regular revision. Advantage may be taken of the visits of salesmen to obtain quotations for various things they can offer, even though there is no immediate call for them, and such prices recorded against future needs. In this way a record is built up, and both the salesman and the purchasing agent feel that the visit is not fruitless.

Directories (Post Office, Sell's, Ryland's, etc.), afford useful records of suppliers, and it is here that the Inspector's reports are of value, as the insertion of a firm's name in block letters does not necessarily imply the relative importance of their works.

Filing Methods

However large or small the purchasing department may be, it is essential that a proper and regular system should be evolved. Members of this Institute know that it is impossible to take any particular system and apply it without modification to a new situation.

The principles may be adopted, but the adaptation must be carried out with great care and regard to effect, and each case worked out to suit conditions.

One main thing to remember is *simplicity*, the fewest number of forms compatible with securing essential data. Judge your efforts by results. Can I promptly lay my hands on the cost of any article whether bought last week or five years ago? From whom did we buy this or that in 1915? Can I promptly find a letter written to me or by me three, four, or five years ago, regarding any subject? If your answer is invariably and truthfully in the affirmative, then your system needs little improvement.

Vertical filing cabinets are now universally adopted, and only one subject should be filed in a cover, so that the entire history of that subject or order is instantly available.

If there are a number of drawings relating to the order, it is advisable to file one set with the order, or in a separate file, while a general drawing cabinet will receive duplicates.

The importance of the duty of filing is sometimes overlooked. It is very unwise to economise in this post and ample repayment is gained by having a competent individual. A cheap man and mistakes is more expensive than a high priced man and efficiency.

Of course, however carefully you may perfect your methods, you are always dependent to a certain extent upon the human element.

It is generally impossible to leave to the discretion of the filing Clerk the decision as to locating certain documents, and whenever any doubt is felt they should be duplicated, or triplicated and filed in each possible

place where they have any reference. You cannot prevent entirely the filing of a document in a totally wrong file. This sometimes happens, and the paper is then irretrievably lost.

Catalogues

As catalogues form a necessary source of information, they should be systematically filed and a double card index record maintained, one of the name of the suppliers, and one of the goods they refer to. Each catalogue should contain discount sheets if supplied.

Everyone who has tried to file catalogues will agree with the difficulty due to variations in size. It is to be wished that makers would standardise their publications to some three or four sizes. It will probably be necessary to have at least six heights and depths of shelves to accommodate all sizes. There are so many methods of indexing and filing that the Author would express no preference, merely remarking that the Dewey-decimal system has much to recommend it, especially if the catalogue library is a large one.

A card index for catalogues may be simplified by adopting two colours, one colour for makers' names and another colour for material or subject.

Invoices

These should first go to the Purchasing Agent, and in his department they must be checked carefully and promptly. In some offices a special record of invoices is kept, and when this is so, it is easy to detect any which may have been twice rendered. A rubber stamp may be used to O.K. the invoices, and a note made on the order at the same time if correct, special attention given to the date when discounts expire, and the cashier notified accordingly. A weekly list of the values of invoices received is of great assistance to the accounts department, and warns them in advance of monies payable. At the same time, it is an index to the Purchasing Agent, and if recorded on the form of a curve, graphically shows the volume of his activities and their fluctuations.

Stores

This department has been so admirably dealt with by Mr. Elbourne in his book, that it is enough to note the great importance of close relationship between this department and the purchasing agent. In some works the stores are under his direction, the desirability of which is open to *criticism, but where this is not the case the closest co-operation should exist.*

The Cost of Purchasing

Most of the departments in an engineering works are producing departments, and the cost of these can be assessed accurately, showing the profit or loss made on every transaction, but the purchasing department is a *spending* department, and careful examination should be made by the chief himself of the expenses of his operations. It is easy to assess these costs, when his department is one of several comprised in a manufactory; salaries of his staff, a due proportion of rent, rates and establishment charges will provide a total, determined with facility.

At the same time the total expenditure for all material passing through the purchasing department, and delivered into store or steamer, will give a figure from which the percentage cost of purchasing may be assessed roughly.

These figures may be subjected to interesting analysis, and as some materials may require more time and more attention from the department in the process of acquirement, a graduated scale is possible, if it is thought worth the study.

Where, however, the purchasing agent acts as a buyer for several companies and obtains quotations for his clients, many of which never materialise as orders, or obtains information regarding markets, firms, methods and processes, the matter becomes more complex, and would form a useful subject for elucidation by our experts of the Institute of Industrial Administration.

Conclusion

The Author has endeavoured to condense within the scope of a short paper some of the prominent facts which go to make an efficient purchasing department and trusts that he has not enunciated many too evident truths in his endeavour to touch on all the essential points.

STEAM METERS AND FUEL ECONOMY

(*Continued from page 3.*)

by keeping a record of the exact amount of steam taken in each case. One reason why steam meters have been neglected is that it is only within quite recent years that they have become a practical proposition. The invention of a reliable and accurate steam meter has, in fact, been one of the most difficult problems in engineering, particularly because of the fluctuating nature of the average steam demand, the presence of varying amounts of moisture from almost zero to 5 per cent. in ordinary non-superheated steam, the variation in pressure, and the swirling motion of the steam in the pipes. These difficulties have, however, been overcome and, whilst Mr. Hodgson's paper was confined chiefly to the "Kent" meter, there are now even different makes of steam meters on the market. In the "Bayer" and "St. John" meters all the steam to be measured passes bodily through the casing of the meter, lifting a tapered plug or a disc off its seat, the amount of lift being proportional to the steam passing, and actuating a pen mechanism which gives a continuous record on a chart.

The "British Thomson Houston," "Curnon," and "Sarco" meters depend on the "Pitot" Tube principle, a disc being inserted between the steam pipe flanges, containing two very small tubes, one facing the flow of steam and one being against. The slight difference in pressure, up to about ¾ lb. per square inch, is proportional to the amount of steam passing. The "Bailey" and "Kent" meters are on the ventur tube principle, the insertion between the flanges of a disc of less diameter than the steam pipe. At the constriction the pressure is slightly reduced, because of the increased velocity of the steam passing, and this difference, as before, is proportional to the amount of steam passing. In both types of meter the discs are connected by metallic piping, full of condensed water, to various types of measuring device to record the small pressure difference direct as lbs. of steam passing in the pipe. These measuring devices depend on one of three principles, the sealed bell floating in mercury, the diaphragm, and the "V" tube.

Generally speaking, steam meters are accurate to 1–2 per cent on

(*Concluded at foot of previous column*)

steady loads, and certainly to 5 per cent. on fluctuating or pulsating loads, and it will be no exaggeration to say that in average cases 5–7 per cent. of the coal bill can be saved by keeping an accurate and continuous check in this way on the steam consumption of the departments and processes in an industrial establishment.

TRANSPORT

Conducted by "M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH THE MANAGEMENT AND CONTROL OF RAILWAYS

Indian Railways in 1920-21

During the year 1920-21 the percentage of net earnings on total capital outlay was 5.06, as compared with 6.80 the previous year. There was a substantial increase in gross earnings, but working expenditure so developed that a decline in net earnings resulted. Many points of interest are brought out in the present Report, of which the following article is a brief summary.

THE Report of the Railway Board on the Administration of Railways in India for the year 1920-21 is, as it has long been, divided into two volumes, the first being the report itself, with a few summary tables of the more important figures, while the second (the larger of the two volumes) comprises the statistical appendices. In this issue, however, the Railway Board have made a notable departure from established usage. Instead of a more or less dry-as-dust account of events, they have in the present report given a most comprehensive summary of the railway position in India, and one that will, no doubt, in the words of the prefatory note, well serve as a medium for conveying to the public a true appreciation of the Indian railway position.

In previous articles published in the Transport Section of INDUSTRIAL INDIA, I have not scrupled to criticise the work of the Railway Board, and it would be more than unfair if I did not, as occasion arises, give praise where praise is due. May I therefore say that the change in the form of the Railway Report is a wonderful improvement, and one that will, in my opinion, have a more far-reaching effect than those who conceived it and carried it into effect had in mind. In these modern days, bare bones and hard facts may be sufficient to elucidate the extent of the railway problem to those "in the know," but, as Sir William Hoy, the progressive General Manager of the South African Railways, has proved, a well-written descriptive narrative detailing the difficulties to be faced, and indicating how the Administration proposes to surmount them, has abundantly justified the labour bestowed upon the work.

The first volume of the Report for 1919-20 contained 37 pages, while in the amended form adopted in 1920-21, 76 pages are occupied with ten chapters of exceedingly interesting information. Within the space at my disposal, it would, of course, be impossible to give more than a brief summary of the report, but I hope that this, at least, will show, as I have already intimated in these columns, that the railway problem in India is an acute one, and that a broad-minded policy of development will be required for the next few years if the problem is satisfactorily to be solved.

Review of Indian Trade

One of the new features in the report is an introductory review of the position of Indian trade, and therein it is pointed out that whereas India has hitherto been primarily an exporting country, with a consequent favourable balance of trade, the outstanding feature of the year 1920-21 was a complete reversal of this position. There was an enormous increase in the value of imports, which reached the record figure of Rs. 336 crores, or 61 per cent. over the previous year's figure, while exports, which amounted to Rs. 256 crores, declined by 22 per cent. as compared with the previous year.

That such a change in trade conditions must have an important influence on the railway position must be obvious to any one, for trade and transportation are so interdependent that any divergence from the normal channel of a large volume of traffic necessarily reacts upon the railways, which have, perforce, to adjust their arrangements to meet the new conditions. This problem, as a matter of fact, is one that has been experienced by nearly every country in the world since the Great War, which brought about such drastic changes in established practices, and created new channels of traffic, that, on the resumption of more normal conditions, important rearrangements had to be made by the railway companies to meet the new requirements.

The unparalleled depression of trade in India was largely due to the fact that towards the close of the year, the Indian markets were overstocked with manufactured goods, of which disposal could not be made, and dealers found themselves face to face with a difficult financial position. Additionally on account of shortness of crops and the fact that the power of India's customers to purchase her produce was restricted somewhat severely, the export trade, as indicated, suffered to an almost unprecedented degree.

In this necessarily brief review it is impossible further to analyse the causes which have contributed to the abnormal trade depression noted above, but special reference to the agricultural position is essential, for, as I have emphasised on more than one occasion in the pages of INDUSTRIAL INDIA, the railway business in India is largely bound up with the agricultural industry. The monsoon, which began well, ended badly, and, as a consequence, the average rainfall

over the plains of India was about 12 per cent. below normal. This had a serious effect on important crops, such as wheat, cotton and jute, but, on the other hand, the season was favourable to the rice crop of Eastern and Southern India. The cotton produced was 39 per cent., and jute 30 per cent. less than the previous year, while rice, which suffered less, was 12 per cent. down, all other commodities showing somewhat similar results.

The shipping position is also of importance in considering the railway position in India, and it is comforting to know that there was a substantial increase in the net tonnage of vessels entering and clearing during the year under review. The trade analysis ends on the note that as the railways of India depend so greatly on favourable trade conditions, it is to be hoped that the tendency towards lower freights and increased tonnage will continue, and that improved internal prospects and the reopening of European markets will shortly terminate the period of depression from which the country suffered during 1920-21.

Railway Mileage in India

On March 31, 1921, the railway systems of India comprised 37,928 miles, this representing the fruits of sixty-eight years' development since the opening of the first Indian line, 21 miles in length, from Bombay to Thana, in 1853. A list given in the report to show the contribution to open mileage represented by each Viceregal administration, yields the palm to Lord Curzon, who, between 1899-1905, was responsible for the opening of 6,255 miles of line. Financial policy has, of course, been the governing factor in this question, but it is at least interesting to reflect —though it is not mentioned in the report—that if each six-yearly period of the sixty-eight years of railway development in India had yielded 6,000 miles of line, as between 1899-1905, the system would now comprise something like 70,000 miles, or nearly double the existing mileage.

Of the 37,000 miles of railway in India, 34,000 miles are single-track, 3,000 miles double-track, and an insignificant percentage in the vicinity of Calcutta and Bombay with more than two tracks. So far as gauge is concerned, 18,000 miles are on the 5 ft. 6 in. gauge, 16,000 miles on the metre gauge, and the remainder either on the 2 ft. 6 in. or 2 ft. gauge. It will be recalled in this connection that, to the March, 1922, issue of INDUSTRIAL INDIA I contributed an article on "The Railway Gauge Problem in India," based on a lecture by Mr. F. G. Royal Dawson, M.Inst.C.E., late Chief Engineer with the Railway Board, who urged the necessity for a bold gauge policy.

In this section of the report, considerable space is given to a description of the methods in which railways in India have been financed, constructed and operated. It is pointed out that the power of the Government to acquire railways has consistently been used, and that there are now only four important lines, viz., the Bengal and North Western, the Southern Punjab, the Delhi-Umballa-Kalka, and the Rohilkhund and Kumaon Railways, which are not the property of the Government. Thus six-sevenths of the total railway mileage of India belongs to the Government, while one-seventh is owned by private companies. On the other hand, the mileage worked by the Government is considerably less than 10,000, and with that worked by native States, less than 12,000, whereas private companies work over 25,000 miles. As noted in the report, and discussed at some length recently in these pages, the propriety of leaving the operation in the hands of private companies has been challenged, and there is a strong diversity of opinion on the matter.

Capital Expenditure

During the year 1920-21, the capital expenditure was Rs. 24,08 lakhs, works, including stores, etc, accounting for Rs. 12,91 lakhs, rolling stock for Rs. 10,15 lakhs, new lines for Rs. 1,02 lakhs, but even this sum, which compares with Rs. 13,49 lakhs in the previous year, and a maximum in any one war year of less than Rs. 7 lakhs, was not sufficient to make up the crying needs, and this point was strongly stressed by the Acworth Committee.

The report proceeds to discuss the question of open line facilities and explains how public criticism in recent years has fallaciously alleged shortage of rolling stock to be *the* remedy for railway congestion, whereas this is only one of the determining factors, and one largely influenced by the question of line and terminal facilities. This inter-relationship was analysed at some length in my recent article entitled "Rehabilitation of Indian Railways," and in an early issue I propose to return to this subject in a discussion on "Indian Railway Developments."

In connection with capital expenditure it may be added that, as I write, I learn by cable from India that the Legislative Assembly has accepted the recommendations of the Finance Committee that 30 crores of rupees should be allocated annually for the next five years for railway purposes solely, so there would seem to be some substantial hope of a relatively speedy improvement in the general transport conditions.

Chapter III of the report discusses the question of rolling stock in an instructive fashion, but as it is more important in this article to deal with the financial results for the year, I will leave rolling stock for attention in my article on "Indian Railway Developments."

Working Expenses

Before the war the "operating ratio," or the percentage of working expenses to gross earnings of Indian railways, ranged round an average of 50, and while, during the crucial war years, owing to the suspension of repairs, renewals, etc., the operating ratio dropped well below the average of 50, it has not since been within measurable distance of it. For the year under review, it reached the unprecedented ratio of 65.54 per cent. as compared with 56.81 per cent. for the previous year. This arose out of a tremendous increase in the working expenses, which advanced from Rs. 50,65,65,000 during 1919-20 to Rs. 60,29,04,000 during 1920-21. On the other hand, the gross earnings advanced from Rs. 89,17,32,000 to Rs. 91,98,76,000, but this quite substantial increase was greatly outweighed by the advance in the working expenses. As usual, there was considerable variation as between companies. For example, the East Indian operating ratio was less than 52, while the G.I.P. and the Assam-Bengal lines were at 77.

The actual distribution of the working expenses for the year between the various spending departments shows the following percentages :—Engineering, 19.82 ; Locomotive, 34.62 ; Carriage and Wagon, 12.12 ; Traffic, 17.60 ; Agency, etc., 7.79 ; Ferry, 9.52 ; and Miscellaneous, 7.53. Under each of these heads there is again considerable variation as between companies, and this would naturally be expected. Take the important item of fuel, for example. Whereas

the North Western, Madras and Southern Mahratta, South Indian and Great Indian Peninsula Railways are seriously affected, the East Indian and Bengal-Nagpur Railways, from their proximity to the coalfields, are advantageously situated, and this is reflected in the expenditure figures. Then, of course, there are other features, too many to be analysed, but it may be added that grades, population, variations in wages to staff, distance from ports, etc., are all of importance in this connection.

A difficulty presenting in this article is to deal adequately with the subject in the space at disposal, but I must not, for that reason, leave out the most important question as to how far the money provided for railway purposes has actually been expended. From the table in the report, it is abundantly obvious that the provision has been entirely an illusory one. Dealing with the figures in crores of rupees, it is noticed that whereas in 1918-19 the provision was 4.07, expenditure was 2; in 1919-20 provision was 9.75, expenditure was 3.59, and last year's provision was at the high figure of 19.75, but expenditurely was merely 5.30! The need for the carrying forward of unexpended money to meet next year's needs could not be emphasised more strongly, and it is to be hoped that the few arrangements will have put an end to this most ridiculous of budgeting a yearly figure and withdrawing it in case it is not spent within the year. Of the amount of Rs. 5.30 crores spent last year, nearly one-half was devoted to renewal of rolling stock, which was badly needed, and the other half to open line works—the replacement of worn-out rails, sleepers and bridges.

It may be added as a note on a subject that cannot here be elaborated that the total number of railway employees on the Indian lines at the close of the year 1920-21 was 157,752, of which 6,901 were Europeans, 11,699 Anglo-Indians, and 733,152 Indians. It is to be emphasized in this connection that, for the past ten years, the number of employees in the first two classes has been more or less stationary, and that the third class has shown progressive increases.

Railway Earnings

During the year 1920-21 the gross earnings of the Indian Railways were Rs. 91,98,76,000, an increase of Rs. 2,83,44,000, or 3.18 per cent. over the year 1919-20, and it is a striking commentary upon the potentialities of the Indian railways to note that, during the past ten years, the earnings have increased by Rs. 40,84,54,000, or 79.86 per cent, despite the inclusion of the war years and the hindrance to earning capacity caused by shortage of line, terminal and rolling stock facilities.

In the ten-year period, goods traffic has grown by 57.62 per cent., representing Rs. 17,53,67,000, while passenger traffic has increased by 113.06 per cent., or Rs. 21,67,81,000. From these figures, and from a perusal of figures over a longer period, as given in the report, it is obvious that passenger traffic is growing relatively much faster than goods traffic, and one can therefore well see the wisdom of the Acworth Committee in recommending that special attention should be paid to the provision of more adequate facilities for passenger traffic. At the same time, it must be borne in mind that, broadly speaking, the goods traffic has not been given the same opportunity for advancement as the passenger traffic. Obviously, and necessarily, passengers receive preference over goods, and it is the latter class of traffic that has been most hardly hit by the serious state of congestion existing on so many lines in India, when goods traffic conveyance has frequently been suspended for relatively long periods.

Dealing further with passenger traffic, it may be pointed out that, whereas in 1871 the number of passengers carried annually was less than 20,000,000, the number for the year 1920-21 was 560,000,000. At the same time, and as is natural, the receipts from goods traffic were much higher than those from passenger traffic, the respective percentages being 52.15, 44.41, and, for "Miscellaneous," 3.44. The major portion of the freight earnings is obtained from the conveyance of traffic falling under the head of general merchandise, while coal which represents about one-fourth of the total traffic—is second. It may be added that the report contains an extremely instructive review of the general development of the coal traffic in India, and deals also with the problems of distribution that have required special attention.

Conclusion

In Chapter VII, which is entitled "Financial Results," appear some useful statistical tables, one showing the results of the working of State-owned railways during the past eight years, each year shown separately, and another—perhaps of greater interest—detailing how the net working profit to Government from all railways has been derived. Owing to space considerations it is impracticable to reprint the tables, but it may be said that the return on capital (State-owned railways) during the year 1920-21 was 4.74 per cent., this, representing the lowest return for many a long year.

On the other hand, during the war the return on capital was abnormally high, largely because working expenses were curtailed owing to the postponement of repairs, etc., the tendency towards higher working expenses naturally being intensified owing to this cause. In the last year before the war working expenses were Rs. 29.36 crores, this figure advancing to Rs. 54.53 crores in 1920-21, thus neutralising the whole of the increase in gross receipts, and bringing the net receipts below the 1913-14 level. In the meantime, also, the liability of Government in respect of interest on capital has risen, the net result being to reduce the working profit below the 1912-13 figure.

Still, even with this relatively unsatisfactory showing for the year, the future is quite reasonably bright. As I have intimated, the Legislative Assembly has accepted the Finance Committee's recommendations for the expenditure of 30 crores of rupees annually for five years, and, almost simultaneously with that report, I notice an intimation that India is to raise a loan for £50,000,000 for railway and irrigation purposes. Nothing, therefore, is more sure than that the Railway Administration intends to smooth out the difficulties of rail transport as far as possible. The main requirement in India is more adequate transport facilities, and with the strong programme now being developed for the purchase of additional rolling stock, the doubling of tracks, the improvement of terminal facilities, and the general remodelling of the railway arrangements, there is little need to despair of the future.

Extensive railway development in India is at hand, and in an early issue of INDUSTRIAL INDIA I propose to deal more fully with this question of development, and include a review of the information on this point to be found within the covers of the most comprehensive and instructive report ever issued by the Railway Board.

Weighing Machines on Railways

As Messrs. H. Pooley & Son were the pioneers in designing and building weighing apparatus for Railway use, we have no hesitation in printing the following description of their latest and most up-to-date types of weighing machinery for the use of Railway Companies both in India and all parts of the world.

GENERALLY speaking, the business of our Railways is that of transport, which may be divided into two classes—the transport of passengers and the transport of goods. The former are carried at so much per mile per passenger, and the latter at so much per mile per unit of weight. It is therefore necessary, with regard to the latter, to have means of quickly and accurately ascertaining the weight of the goods carried.

This point seems to have been fully appreciated in the early days of railways by Messrs. H. Pooley & Son, who, in June, 1835, supplied to the Liverpool and Manchester Railway their first platform weighing machine. This type of machine has since been adopted by almost all the railways of the world. Previously, small packages were weighed either on equal balances or beam scales. This method was cumbersome to use, and necessarily involved considerable waste of time.

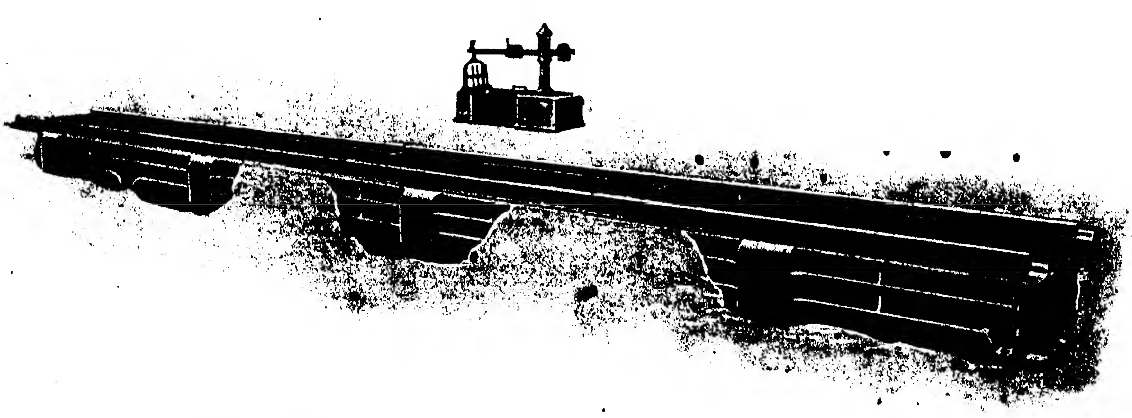
Following speedily in the wake of the platform weighing machine, there came the road and rail weighbridges, fitted with steelyard and loose weights. Development from this time forward became very rapid, owing to the unique position Pooley's were in with regard to railways, to whom they were the only suppliers; as they also held contracts with most of the existing railways for the upkeep of their weighing apparatus they were able to see at first-hand the requirements of the various departments of railways, and quickly brought out inventions to meet the various demands, and in 1847 constructed a machine for balancing locomotive engines, by recording the weight on each wheel. One feature of this machine was the steelyards which were constructed to be used without loose weights, and in the Great Exhibition of 1851 they had the honour of being awarded the first prize medal.

Since that time a steelyard without loose weights has been universally adopted. The natural development was now seen to be the automatic indication of loads without any assistance from the weighman.

The first indicator was in the form of a dial, and to-day the dial form is probably the most frequently seen. Most of the leading railway companies at home and abroad have this type of indicator in use to-day. It has been fitted to railway weighbridges up to 30 tons. The "Quadrant" indicator is more stable and quicker than any other known form, the result being that traffic is received and despatched in considerably less time than formerly. Up to comparatively recent times, railway wagons were principally of the four-wheel type, having capacities up to 10 tons. To-day the majority of the wagons, especially abroad, are of the bogie type, each bogie having four wheels, with capacities up to 50 or 60 tons.

With a train composed of mixed traffic, that is, long and short wagons, the necessity for weighing these without uncoupling became of great importance. Although Pooley's had previously constructed weighbridges up to 75 ft. this did not meet the case. The combined weighbridge was introduced, as shown by illustration No. 1. These weighbridges have been constructed with from two to four units coupled to one steelyard or indicating mechanism. The length of each unit is carefully rated, so that wagons have a maximum of run on the machines.

Either one or all of the units may be connected or disconnected instantaneously at will, so that, no matter on which unit of the combined bridge the wheels may be placed, the com-



Pooley Four Unit Combined Weighbridge

bined load of the wheels may be accurately recorded, in spite of the fact that other units of the bridge may have loads imposed upon them. There is no practical limit to the number of units that may be employed. The simplicity of the Pooley compensating device enables the number of units to be extended indefinitely.

A number of railway weighbridges have been fitted with the automatic "Quadrant" indicator, the greater part of which have been sent abroad, testifying to the foresight and up-to-dateness of the Indian engineers. This indication is shown in illustration No. 2.

The weighbridge in use on railways is not confined to railway wagon machines. Road weighbridges must, of necessity, be put down to weigh the road traffic to and from the railway goods sheds. The introduction of road traction has necessitated the re-designing of the road weighbridge. Whereas previously the loads to be weighed were conveyed in either two-wheeled carts or bullock wagons of a total weight of from five to six tons, the motor lorry imposes a load of from ten to fifteen tons, with a wheel base of approximately 16 ft.

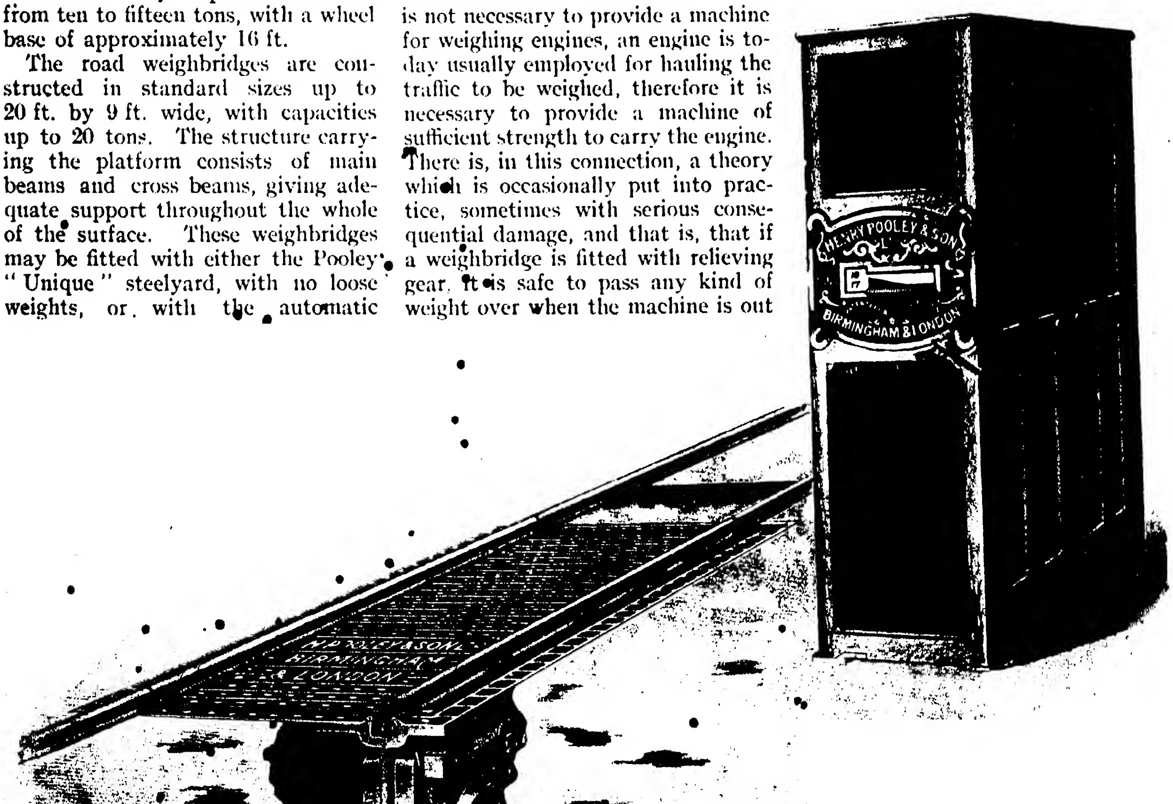
The road weighbridges are constructed in standard sizes up to 20 ft. by 9 ft. wide, with capacities up to 20 tons. The structure carrying the platform consists of main beams and cross beams, giving adequate support throughout the whole of the surface. These weighbridges may be fitted with either the Pooley "Unique" steelyard, with no loose weights, or, with the automatic "Quadrant" indicator. The principal Home railways have adopted the "Quadrant" indicator for road weighbridges, two units generally being supplied, with the weigh office between the platforms. One clerk can readily cope with both inward and outward traffic. This arrangement, which is shown in illustration No. 3, has proved very successful.

The position of weighing machines generally is of vital importance; for instance, truck weighbridges should always be fixed in straight, level roads, and, as far as possible, in a special weighing road, not, as is the usual practice in England, in the road over which most of the shunting takes place. If this is unavoidable, then a machine with two roads should be adopted, one being the "live" or weighing road, and the other the "dead" or shunting road, and the lever controlling the points should be placed in the weighing-house, so that the weighman is responsible for all traffic which passes over the live road.

Again, with truck machines the fact is often overlooked that while it is not necessary to provide a machine for weighing engines, an engine is to-day usually employed for hauling the traffic to be weighed, therefore it is necessary to provide a machine of sufficient strength to carry the engine. There is, in this connection, a theory which is occasionally put into practice, sometimes with serious consequential damage, and that is, that if a weighbridge is fitted with relieving gear, it is safe to pass any kind of weight over when the machine is out of gear, but this is quite wrong. The idea of relieving apparatus was to take the strain and wear off the lever knife edges when it was desired to run traffic over which did not require to be weighed, but, with the exception of machines which have been specially built to carry a heavier load out of gear than in gear, the relieving of the machine does not in any way increase its carrying capacity. The old standard truck machine was 20 tons' strength. The standard adopted by most Indian railways to-day is 80-100 tons.

In the older types of machines it was customary to provide relieving gear; to-day it is never fitted, as experience has shown that if the relieving apparatus is used, it does quite as much, or more, harm to the knife edges, to be constantly putting in and out of gear, as to allow the loads to roll over with the knife edges in gear.

The position of the cart or road wagon weighbridge is also a very important point, and care should be taken to fix them in a level road, or



Railway Weighbridge

at the top of an incline, rather than at the bottom, where they become a cesspit for all the mud and water from the surrounding roadway. It is also advisable to fix them in such a position that traffic not requiring to be weighed can pass along the side of the machine, but if a full-width roadway cannot be provided, let all the traffic pass directly over the machine, rather than half on and half off. A kerb (granite or length of rail) along the off side of a cart machine is a most useful addition, since it compels the traffic to pass straight on and off the machine. There is nothing so detrimental to the accuracy of a cart weighbridge as running across the corners or turning the load when on the machine.

Particular care should be taken to see that the pits are well drained, and the surface of the roadway all round the machine should be paved with setts.

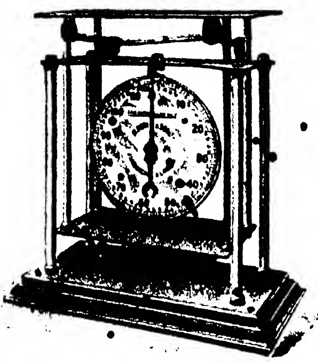
The position of platform machines fixed in goods decks is well worthy of the careful attention of the traffic department, as well as the engineer. The front edge of the deck is perhaps the best position, with the pillar and steelyard as close as possible to the crane, and not placed in the way of the general run of the traffic up and down the shed, or where the crane hook just swings round and knocks the pillar off with a piano case or the like.

The pits of these machines should also receive careful attention, and if the floor of the shed is concrete, as seems to be becoming fairly general in new sheds, then small ventilating grids should be fixed at either side of the machine, to enable a current of air to pass through and prevent sweating. This point also applies to machines fixed on passenger platforms.

Perhaps the department which suffers most in improper positioning, and consequent abuse, is the busy parcels' office, where large quantities of small parcels are weighed over spring dial machines. Improvements have certainly been made in this direction in some of the largest depots, but there does not appear to be any real recognition of the fact that a dial machine is a very delicate instrument, and not a portion of the counter or floor upon which it may happen at the moment to be in use. A dial parcels' machine must be placed in a level position, and it should have only one position. A very good plan is to let it have its own particular stand; if it must be moved about, then let the stand be on wheels, converting it into a small trolley. A very useful alternative type, manufactured by Pooleys, is also illustrated (No. 4). This machine has the weighing platform over the top of the dial, and the machine can be inserted into the parcels' receiving counter, so that the weighing platform forms actually part of the counter. The parcels are then merely pushed along on to the weighing platform without the necessity of lifting.

The railway companies abroad are in the fortunate position of having the benefit of the accumulated experience at home. The conditions are somewhat different, due to the opening up of new country. There are generally long stretches of open country, making it possible to utilise large capacity wagons. This, in its

Quadrant Indicator on Road Weighbridge



No. 4

turn, generally entails long weighbridges, or weighbridges of the unit type.

Another point to be considered is the fact that in a good many cases native labour is employed. It is, therefore, desirable to have all indicating mechanism of the simplest form, and of such construction that it is not readily deranged; in fact, it should be made as fool-proof as possible.

The "Quadrant" indicator is eminently suitable where automatic indications are desired. Its construction is simplicity itself. There are no gears, bands, or rotating spindles of any description. The maintenance cost is very low, and the accuracy life of the indicator is very great. Where no loose weight steelyard is preferred, the "Unique" type is to be recommended. The notches are cut in a hard steel bar adequately supported by, and secured to, the main steelyard. The weighbridge proper, levers, beams, platform, etc., is well designed, the accumulated experience of nearly 100 years being employed to produce the most efficient and up-to-date result.

Wagon weighbridges for abroad have to be made in various gauges of rails from 2 ft. to 5 ft. 6 in., also the indicating apparatus has to be graduated to suit the country for which the machine is destined. In many cases steelyards and indicators have two graduations, such as metric and avoirdupois, Chinese and metric, Indian and avoirdupois, and so on. In the Pooley "Quadrant" indicator, with two graduations, the indications in both denominations are viewed simultaneously at eye level.

Modern Tendencies in Locomotive Design

Professor Carlier, of Liege University, gave at the recent Institute of Transport meeting in London, a very interesting review of modern tendencies in locomotive design, especially on the continental railways.

The idea of using a condensing steam turbine for locomotives instead of the ordinary reciprocating non-condensing steam engine is being developed in various countries, and, as is well-known, the British "Ramsay" locomotive constructed on these lines is now undergoing trials. In Germany, Krupps have now also built a similar locomotive with a "Zoelly" condensing steam turbine, whilst in Switzerland, A. G. Escher-Wyss of Zurich, and the Locomotio-Maschinenfabrik of Winterthur, are experimenting on the same lines. In the Swiss designs there are two turbines, one for moving ahead and one for backward movement, arranged on a common shaft, the surface condenser being fixed underneath the boiler behind the turbine.

In Norway a similar type of locomotive using the "Ljungstrom" turbine is being constructed, and the Company Officine Meccaniche in Italy is engaged on the same problem.

The famous Cockerill firm of Liege, in Belgium, are also designing a condensing locomotive, but with the use of the ordinary reciprocating engine.

The "Diesel" locomotive continues to attract much attention, and enormous developments are pending in this direction. Sulzer Bros., in Switzerland, may be said to be the pioneers, and they have had experimental "Diesel" locomotives running since before the War.

They are now constructing an improved type based on this long experience. The "Diesel" engine used is of the four cylinder type, with a development of 16,000 H.P. at 300 revs. per minute. The pistons of the engines are connected with a crank axle, which is linked at each end by connecting rods and winches to the two driving axles. The frame is supported by two bogies, one at each end, and between them are four driving wheels, the total weight of the engine being 95 tons.

In America, on the Minneapolis, St. Paul, Rochester and Dubuque Railway, experimental trials are being made with a combined "Diesel" engine and electric drive locomotive. This has two eight cylinder 175 B.H.P. "Diesel" engines direct coupled to two 600 volt. compound wound electric generators.

Other experimental "Diesel" or similar type of internal combustion engines are the "Pieper" in Belgium and France, and the "Strang" and the "Westinghouse" in America.

Indian Locomotive and Rolling Stock Requirements

On the basis of the Railway Board's estimate of minimum capital requirements, the Railway Finance Committee have recommended an expenditure programme of 150 crores for the next five years. According to a Bombay message, two-thirds of this large sum is to be spent on locomotives and rolling stock, and it is computed that the number of locomotives required by the Indian railways during the next five years is over 2,000, the allocation between the various companies being shown below:

East Indian Railway	760
Great Indian Peninsula Railway	314
Bombay, Baroda, and Central Indian Railway	185
Bengal Nagpur Railway ...	160
North Western Railway ...	150
Madras and Southern Mahratta Railway	140
South Indian Railway	195
Oudh and Rohilkhund Railway ...	81
Eastern Bengal Railway ...	73
Assam-Bengal Railway ...	43
Burma Railways	57
	2,158

The number of passenger cars and freight vehicles required during the next five years is 6,756, and 55,556 respectively, these being allocated fairly regularly over the five years.

Aerial Ropeways

This, the concluding paper of a series of articles on Aerial Ropeways, deals with some typical installations in India and the Far East.

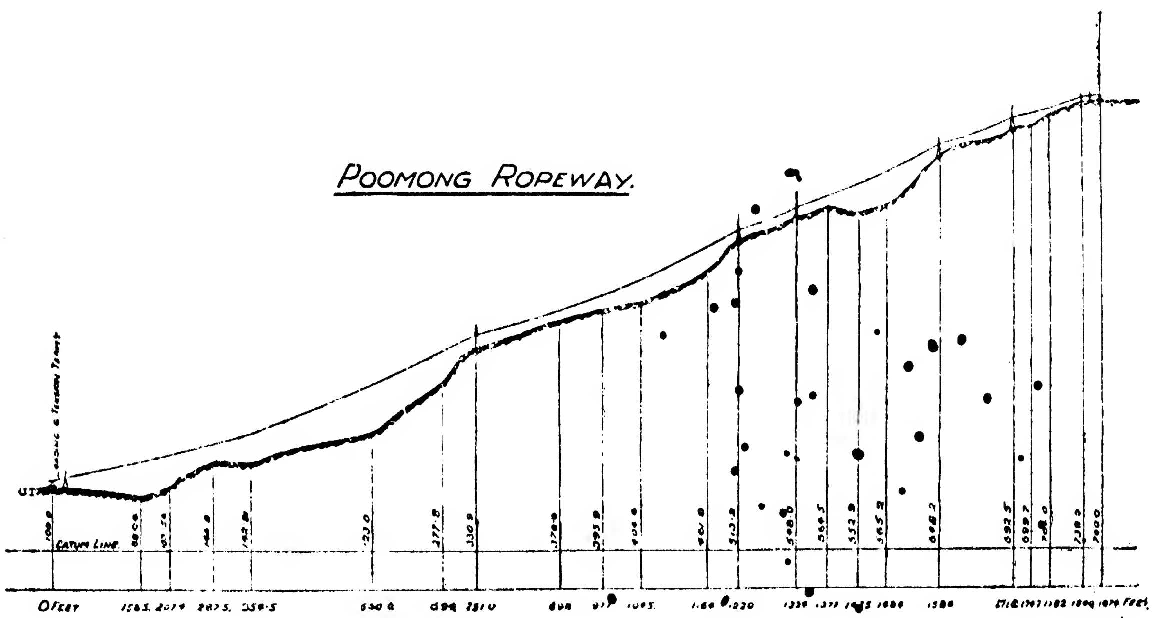
In the short series of articles—of which this is the last—it would obviously be impossible to deal on a really adequate basis with the numerous ropeway installations operating satisfactorily and economically at many and diverse locations. It is hoped, however, that sufficient has been said to demonstrate the exceeding utility of this flexible transport medium, and to prove that the ropeway has strong claims for consideration as a labour-aiding device no less than a means of transport where others are lacking.

The first article in this series dealt generally with alternative systems of ropeways, the second described an extensive installation functioning as a railway extension, the third referred briefly to the utility of ropeways for the handling of iron-ore, coke and refuse at works in Great Britain, and it is now the intention to develop the subject by reference to typical installations in India and the Far East. For the information on which this article is based we are principally indebted to Messrs. George Cradock & Company Limited, Wakefield, and Messrs. Ropeways Limited, Eldon Street House, London, E.C.2, by whose courtesy we are also able to reproduce illustrations depicting the ropeways described.

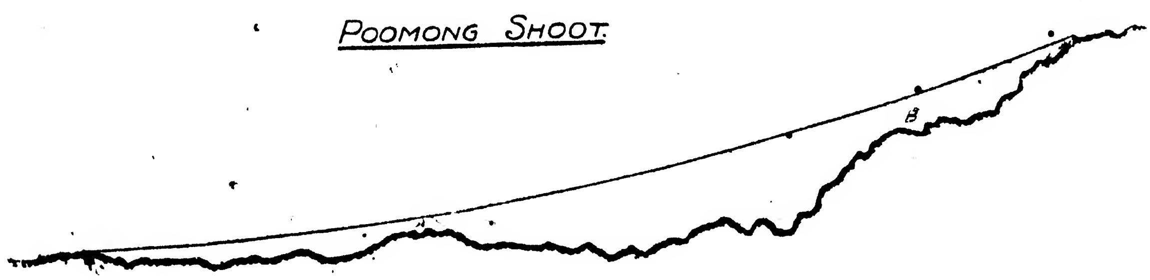
The Poomong Tea Shoot and Ropeway

An interesting ropeway now operating with satisfaction is that provided for the Darjeeling Tea and Chinchona Association, at the Namring Division. Originally the tea-leaf was transported laboriously by pack ponies, the journey occupying two or more hours in bad weather, and as the necessity for an improved system became imperative, Messrs. George Cradock & Company Limited, through their Calcutta Agents, were given an order to supply and erect a complete plant.

As at all other locations the first thing to be done was to survey the



POOMONG ROPEWAY.



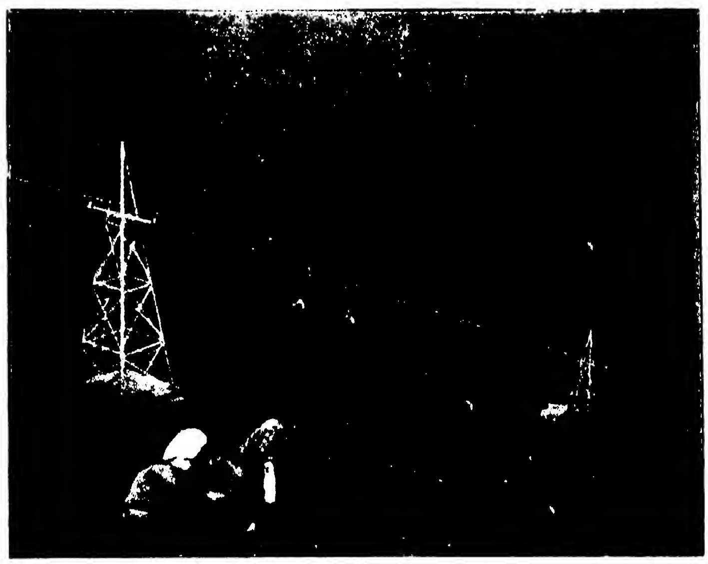
POOMONG SHOOT.

George Cradock & Co. Ltd

site, and ascertain the best course to pursue. Owing to the peculiar formation of the ground surface, the location of a ropeway direct from the loading point to the factory was considered too costly, and as there were upper and lower gardens with the factory roughly 65 ft. below the level of the upper loading point and 640 ft. above the lower loading point —the provision of a shoot between upper and lower gardens and a ropeway from the latter to the factory was finally decided upon. This course had the double advantage of effecting economy in connection with the installation by reason of the shortening of the ropeways, and also of providing easy communication between the lower gardens and the factory—a scheme not in the original proposal.

The shoot which has been provided consists of a rope of high tensile steel, the carriers employed for the purpose of transit weighing under 3 lbs. each, and moving direct from the higher to the lower gardens by gravity. The shoot had a clear span of about 4,280 feet and passes over extremely broken ground to within a few feet of the ropeway loading terminal, located about 1,980 feet from the factory and some 640 feet lower.

The upper end of the shoot strand passes over a trestle to a fixed ground anchorage, while the lower end is attached to a heavy suspended weight designed to keep the tension automatically constant. The time taken for a load, usually weighing about 100 lbs., to run down the shoot is about 1½ minutes, and owing to the



George Cradock & Co. Ltd.

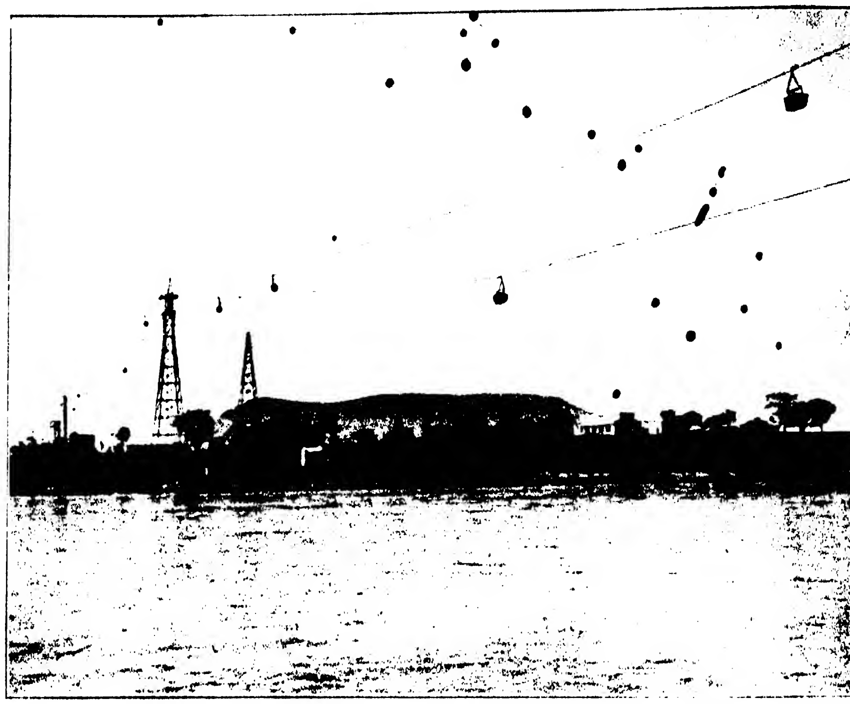
Fixed Clip Type

George Cradock & Co. Ltd.

form of the curve taken by the shoot strand the loads come to rest just before reaching the terminal. The plant has a carrying capacity of 100 loads per hour, each load being roughly 100 lbs.

The system of ropeway adopted is the fixed clip single endless rope type, the line being about 1,980 ft. long with a rise from the lower gardens to the factory of 640 ft. It is driven by a belt from a pulley on the factory shaft, and is of a type which experience has shown to be especially suitable for work on tea estates, where only native labour is available. A steel rope spliced endless takes a half turn on each of the 8 ft. diameter pulleys, and is supported by pulleys on trestles between terminals. The lower terminal pulley is arranged so that its position can be adjusted to give the required rope tension.

The driving gear at the upper end is of simple arrangement. A belt from the factory shaft drives a pulley



Messrs. Ropeways, Ltd.

on an overhead horizontal shaft through bevel gear and acts direct on the terminal pulley. A brake operated by means of a convenient hand wheel is provided on the overhead shaft in order to prevent runways in the remote contingency of an accident to the driving belt.

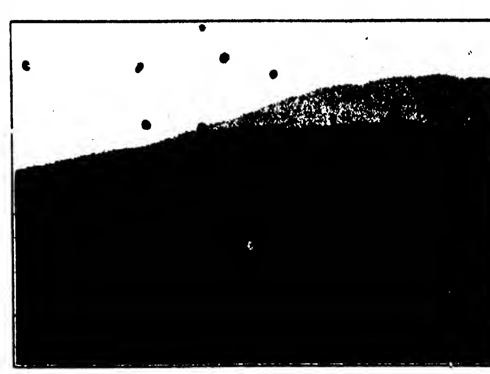
In regular operation the rope moves continuously at a speed of from 2½ to 3 miles per hour, and the carriers—provided with hooks for the facile attachment and detachment of loads—are spaced at equal distances along the rope by means of clips or grippers, designed smoothly to pass over the trestle pulleys and round the terminal pulleys. The carriers can be loaded and unloaded without difficulty after a little practice.

The wire rope gravity shoot and aerial ropeways were erected in 1917, and the manager of the Namring factory states that after three years experience he is able definitely to show that the cost of transporting the tea-leaf and firewood is only about one-tenth of what it formerly cost, to say nothing of the saving in the wear and tear of the roads over which the pack-ponies were wont laboriously to travel. Additionally the transport time, which was approximately two hours per journey under the old conditions is now reduced to twelve minutes. The whole plant is working exceedingly well, and giving entire satisfaction.

The Mahanadi Dam Ropeway

It is not, however, merely in the transport of light material that the aerial ropeway finds a useful place. As we have previously described, relatively heavy traffic may conveniently be moved by this medium, while at many locations light aerial ropeways have been erected for the transfer of passengers and repair materials from place to place. One such has been provided in connection with the dam on the River Mahanadi at Raipur, in the Central provinces of India, where the ropeway is some 1,500 feet long, the galvanised carrying rope being 1⅛ in. diameter and the hauling rope ⅜ in. diameter.

The heavy carrying rope is attached to a ground anchorage at one end, and passes through the steel trestles to the other end of the line, where it is attached to a tension weight, the rope being supported on roller saddles so that the carriage may pass freely through the trestles. The hauling rope is arranged to take one or two turns round the hollow rim drum of a hand winch on the carriage, which is of light steelwork construction suspended from two grooved wheels travelling on the carrying rope. The carriage accommodates four men, besides the winch, which is of simple construction, consisting of a narrrow drum with hollow rim to take the hauling rope. It may be added that the passengers may propel themselves to and fro along the ropeway, and where desired the carriage may be permitted to run by gravity when



George Cradock & Co. Ltd.

travelling down the rope sag towards the middle of the spans.

In the case of a similar ropeway constructed a few years ago for the Jelum River Dam in the Punjab, the ropeway is over 4,000 ft. long, with only seven intermediate supports.

The Hardwar Cableway

Cableways differ from ropeways essentially in the fact that they merely comprise a single span between end towers, and are used in preference to the latter where considerable difficulty presents in the erection of intermediate supports. One such cableway crosses a portion of the River Ganges, near the town of Hardwar. It is designed to raise a load of 2¼ tons from any point in a span of 1,400 feet at a speed of 120 ft. per minute, and to carry it along at a speed of 360 ft. per minute, and also to deposit the load at any desired point. The end towers are 72 ft. high and are rigid on their own bases without the aid of stay ropes. The hoisting and hauling machinery are arranged for electric drive, and all the operations are in charge of one native attendant.

While there are many small differences in the installation of such

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a cableway, as compared with the equipment of an aerial ropeway, it is hardly necessary to describe them in detail, as the requirements will naturally vary according to the specific locations and conditions. Suffice it then to say that experts in the construction of ropeways, cableways, etc. are willing at all times to give the benefit of their wide experience to those desiring information on the subject, and that given reliable particulars of transporting length, contour of ground, capacity required, and other necessary details, they can advise one or other of the many systems that will prove of greatest advantage in the given circumstances.

Other Ropeways in India and the East

In No. II. of this series I described the Dorada Extension Ropeway, designed and installed by Messrs. Ropeways, Limited, who have also done considerable work in India and the East. Among the larger plants erected by this firm in India are those at Kashmir, Mussoorie, Nepal, Dehra Dun and Nanital, while they have supplied a bi-cable installation at Manharpur for the Bengal Iron and Steel Company, together with plants in Japan, Australia and elsewhere.

At a later date it may be found desirable to give additional information regarding these and other ropeways, but considerations of space prevent any further elaboration at present. A few words might, however, be said in conclusion as to the necessity for expert consideration of

Messrs. Ropeways, Ltd.

the transport problems that might be solved by means of ropeway installations. As the manufacturers well say, it is only by expert advice that every problem of design and working can be solved in the best way.

The usual particulars required before an estimate can be formulated are set out in detail below, these naturally varying to some extent in accordance with the needs :—

What is the length of the proposed line ?
How many tons have to be transported per working hour ?
What is the nature and weight per cubic foot of the material in the state in which it would be carried ?
Have individual loads to be kept at definite weight, or can they be arranged to suit capacity of line ?
What is the character, flat, hilly or mountainous, of the ground to be traversed ?
If railways, roads or rivers are crossed, give width and necessary clearance required.
Can proposed ropeway be taken in a straight line from terminal to terminal ?
Is the mean grade in favour of or against the loads ? What is the approximate difference in height between terminals ?
If loads are to be conveyed in both directions, give quantity each way.
State whether power is available, and what form.
What are the exact terminal requirements in connection with loading and unloading ?

The submission of information of this character to either of the firms mentioned in this article, or to those previously mentioned, would enable approximate estimates to be made for ropeway installations, but if definite tenders were desired, it would additionally be necessary for a section of the ground over which the line would pass to be submitted.

It is only within comparatively recent years that ropeways have gone ahead, but the great needs of the future, the vital fact that labour costs in all parts of the world are now far too high for manual labour to be permitted to perform functions that can more cheaply be done by other means, and the increasing recognition of the utility of ropeways would appear clearly to indicate that the use of ropeways is yet relatively small. Within the next few years, we believe that many more plants will be installed, for both within the boundaries of industrial establishments, where there is a considerable amount of internal transport, and in the wider spheres of undeveloped territory, there is tremendous scope for the ropeway, which has abundantly proved its claim to be a remarkably cheap and flexible transport medium.

Questions and Answers

The Editors will be pleased to render any assistance possible to their readers in solving mechanical or technical problems.

QUESTION.

To the Editor, "Industrial India."

DEAR SIR,

We have been in receipt of the two numbers of INDUSTRIAL INDIA, and say that the journal is admirable in all respects and deals with the subjects of industrial development in this country in a very comprehensive manner.

We propose to start a concern for making knives, scissors, forks, spoons etc., etc., *i.e.*, Cutlery business at Meerut. Will you kindly introduce us to any firm in India, or abroad where we can get necessary machinery and other equipments and a rough plan to enable us to draft out the proposals into a working shape.

A detailed reply will oblige,

Yours faithfully,

THE HINDI SAHITYA LTD.

ANSWER.

DEAR SIR,

Replying to your enquiry addressed to our Bombay Office, regarding the starting up of a concern for making knives, scissors, forks, spoons, etc., in which you ask us to introduce you to firms who supply the necessary machinery for the manufacture of such articles, we have pleasure in giving you herewith the names and addresses of such firms, and in order to save time, we are sending you under separate cover, catalogues, etc., which these firms have kindly supplied and which you will find give very full details regarding the necessary machines for your purpose. We are also sending you estimates of cost, which the firms referred to have supplied.

After you have perused this information you will doubtless be in a position to know more definitely what your requirements are likely to be, when we would suggest that you get into direct touch with the makers of the machinery, as shown in the catalogues which we have supplied.

The following are the firms who have sent us particulars of the necessary machinery for meeting your requirements: Messrs. J. Rhodes & Sons, Ltd., Grove Iron Works, Wakefield ; Messrs. Taylor & Challen Ltd., Derwent Works, Birmingham.

Yours faithfully,

EDITOR "*Industrial India.*"

QUESTION.

Editor, "Industrial India."

SIR,

I shall be highly obliged if you will be kind enough to publish your reply to my queries on the following industrial subject in the next issue of your valuable magazine. Subject :

Manufacture of woodscrews and wire nails in India.

Upon inquiry from the Director of Industries, Bombay, I have come to know that there is not a single factory in India, which manufactures either wood screws or wire nails, and as we know these manufactures are imported in large quantities from foreign countries, namely America, Japan, Germany, United Kingdom, etc., so I want to know whether it will be possible to manufacture in India, wood screws and wire nails of the same quality as imported at present, considering the present state of industrial affairs and also our dependence on foreign countries for raw materials, viz. : Basic Screw Wire, which too is not manufactured at present in India.

If your reply be in the affirmative, in what way will you be able to help me, or whom should I approach

for help and guidance in gathering various kinds of information that will enable me to prepare a statement of required capital and the net profits accruing out of the same?

No doubt I have gathered some information from different sources, which assure me of the possibility of such manufactures in India, but to doubly assure myself I have ventured to take your expert advice which I hope you will gladly give and oblige a humble reader of your valuable magazine.

Lastly, I request that you will favour me with all kinds of information which are in your opinion necessary for me to be aware of, so as to enable me to materialise this idea and to put it into practice.

Thanking you in anticipation,

I remain, Sir,

Yours truly,

"SCREW INDUSTRY."

ANSWER.

DEAR SIR,

Replying to your enquiry addressed to our Bombay Office, in which you ask for particulars regarding machinery for the manufacture of Wood Screws and Wire Nails in India, we now have pleasure in supplying the information required and regret the delay in answering your letter, owing to the difficulty of finding the manufacturers of this somewhat special plant.

We do not know why these articles should not be manufactured in India, and it would appear a most suitable branch of industry for development.

We are sending you under separate cover in order to save time, particulars which we have collected from three different manufacturers, which you will find gives very full information regarding the manufacture both of Wood Screws and Wire Nails, including a quotation for the different machines which are necessary for the complete process and for plants of different outputs.

The information we are sending you will doubtless enable you to formulate the definite requirements for a specific factory, when we would suggest that you get into direct touch with the firms mentioned below, who would be very pleased to give you the fullest information regarding the starting up of the plant which you anticipate.

The following are the firms who have supplied the above information referred to: Messrs. Vernon Proctor & Co., Foster's Buildings, 22 High Street, Sheffield; Messrs. Greenwood & Batley, Ltd., Albion Works, Leeds; Messrs. William Grice & Sons, Ltd., Fazeley Street, Birmingham.

Yours faithfully,

EDITOR, "*Industrial India.*"

QUESTION.

CHAMBA STATE,

The Editor, "Industrial India."

SIR,

I shall feel obliged by your kindly supplying me with the following information at an early convenience.

I want to start a small Oil Mill to work mustard seed. The available quantity of seed per annum is between 100 and 150 tons.

I want to know what plant I shall require to work this quantity, and what will be its cost and what quantity of power will be required to work the plant. I intend to use either water power or electric drive. This is an isolated place in the hills. We cannot import seed from other places nor can we carry it to other centres. Our mustard is very superior to that of the plains. It gives best oil. Is Anglo American system best of all?

I shall also require to clean and bleach the oil. What plant will be required for this purpose?

I shall be grateful by your supplying me with an idea of the cost and kind of machinery I require.

The last 40 miles of the journey from the railway terminus is through hill tracts, allowing the use of mules and men only, so the machinery is to be as portable as possible.

Yours faithfully,

(*Signed*) GOPUL SINGH.
Supt. of Works,
Chamba State,
Punjab, India.

ANSWER.

Dear Sir,

Replying to your letter addressed to our Bombay Office, in which you ask us to supply you with information regarding a small oil mill to work mustard seed, we now have pleasure in sending you details of plant together with particulars and also illustrations which have been supplied to us by Messrs. Manlove, Alliott & Co. Ltd., Engineers, Nottingham.

Mustard Seed is best dealt with in Anglo American Presses, and assuming 300 working days per year, the small self-contained "Asian" Oil Mill of the Anglo American Type, illustrated in circular 815, having a capacity of 10 cwts. of seed per day of 11 hours, would be exactly in accordance with your requirements.

This small mill is constructed in order to give results equal to those obtained by the largest and most powerful mills, and can readily be driven by an electric motor, or in case of necessity by bullock or pony gear.

There should not be any difficulty in transporting the mill in parts, by means of mules, but would have to be specially packed to suit these conditions.

The makers suggestion would be to put down a small mill with two presses. This would allow of continuous working and in addition be easier of transport.

The present price for this installation, packed for shipment and delivered F.O.B. British Port is £606 10s. (Six hundred and six pounds ten shillings.)

The oil would require to be filtered, for which purpose the makers suggest the smallest size Filter Press, or alternatively, in the case of such a small mill this might be done by means of gravity, or a Bag Filter, that is to say the oil passed through bags made of Filter Cloth and allowed to filter by gravity.

The resulting oil after filtration should be quite satisfactory for ordinary use, but if a medicinal quality oil is required, it might be found an advantage to bleach and refine. The makers do not think the quantity available would warrant the expense incurred in providing a complete refinery; and doubtless you would be able to obtain satisfactory results by means of small tanks fitted with heating coils, agitation being given to the volume of oil by means of wood stirrers hand operated.

The F.F.A.'s, would be removed by caustic soda solution, added whilst the oil was in a state of agitation. After this has been done the oil would be allowed to settle and drain off into a smaller vessel fitted with a heating coil, where it would be mixed for 10 to 15 minutes, with five per cent. of Fullers Earth, or five per cent. of Mixed Fullers Earth and Animal Charcoal, in equal quantities, after which it could be passed through the filter press above referred to, the oil being kept in a state of agitation until the completion of the filtering operation.

The approximate cost of the two tanks fitted with coils, would be about £40 (Forty pounds.)

A mechanical refinery fitted with mechanical agitators, and consisting of neutralising vessel, bleaching and washing vessels, together with blower for the purpose of agitating air, would cost approximately £200. (Two hundred pounds.)

The Oil Mill would require about 9 to 10 H.P. for driving, whilst the Filter Press Pump would require about 1 H.P.

It is assumed that steam would be available for heating the meal in the kettle, but if not this would have to be specially constructed to allow of fire being used.

Should you require any further details regarding the plant proposed and you will get into direct touch with the makers, they will be very pleased to give you any further details which you may require.

Yours faithfully,

EDITOR, "*Industrial India.*"

THE GRAMPIANS WATER POWER SCHEME

THE Bill for the Grampians Water Power Scheme in the Highlands of Scotland, promoted by the Hydro-Electric Development Company, has just (May 23rd) been passed by the House of Commons. The area involved in this scheme is over 400 square miles in the north of Perthshire and the south of Inverness-shire, and will involve the development of about 56,000 H.P. When completed a further scheme will then be proceeded with, covering the whole valley of the River Tay. The essential portion of the present scheme is the building of dams at each end of Loch Ericht. At present this loch is about 16 miles long and very narrow, only 1 mile at its widest part, and the outlet is the River Ericht, which runs by a steep descent of about 5 miles into Loch Rannoch, about 9½ miles long and ¾ mile wide. The dams at Loch Ericht, one of which will be 35 feet high and the other 50 feet, will raise the level of this loch by about 40 feet, so that the storage capacity will then be 80,000,000,000 gallons. It is proposed also to erect a small dam at one end of Loch Rannoch, and raise the level about 4 feet, so that the storage capacity will be 10,000,000,000 gallons, whilst 5 miles lower down from Loch Rannoch, another dam will form a reservoir on the River Tummel, with a capacity of 450,000,000 gallons.

The water head at the Ericht power station is 450 feet, and the power generated will be 16,000 E.H.P. continuous. The Rannoch power house will have a normal output of about 14,000 H.P. although in times of flood 28,000 H.P. will be available. Other portions of the scheme are the construction of a tunnel to connect Loch Ericht with Loch Garry, and the raising of the level by dams of two small Lochs, Am Duin, and An-T-Seilica, and the connection of the latter with Loch Cuaich. When this is completed the Ericht power house will be increased to 26,900 H.P. The remaining portion of the scheme is the utilisation of another Loch, Mhaire, the power station of which with a head of 650 feet will generate 4,200 H.P., whilst the fourth station on Loch Garry, with a head of 870 feet, will give about 7,500 H.P. The current generated is to be 3-phase at 6,600 volts, and for transmission purposes 100,000 volts will be used with overhead wires. It is expected to supply both the Glasgow and Dundee areas, each of which are about 70 miles away.

A RECORDING METER

INFORMATION is just to hand from America of the invention of an electrical apparatus, which gives a continuous record of the acidity, or alkalinity of boiler-feed water. This invention is the work of Robert C. Arthur of the Public Service Electricity Company, Perth Amboy Electricity Station (New Jersey, U.S.A.), and Earl A. Keller, the Research Engineer of the Leeds and Northrup Company of America, and was devised to get over the serious corrosion due to acid feed water on the Perth Amboy plant. The ideal conditions for boiler-feed water are a very slight permanent alkalinity. The serious results of acid feed-water do not require to be emphasised, but excess alkali is also objectionable because, after the lapse of years, it tends to make the boiler plates brittle, to dissolve the zinc in the gunmetal fittings, and to cause the water in the boiler to froth and to increase the priming action.

There are two general methods available for the determination of alkalinity. The first is the usual titration of a sample of the water with a very weak standard acid solution, using the ordinary indicators such as litmus, methyl orange, or phenolphthalein. This is quite impractical for continuous testing, because of the time wasted in taking the samples and carrying out the determination.

The second method is an electrical one in which two electrodes are immersed in a small bye-passed flow of the water, and a recording potentiometer used to record the resistance to the passage of a current between the electrodes. The apparatus is arranged on the principle of the Wheatstone bridge, that is, the current is split up into two paths, one through the boiler-feed water, and the other through a very fine standardised and graduated resistance coil. These paths are connected by a sensitive galvanometer in the centre, and the standard resistance is provided with a sliding key, so that it can be altered at will. When the current flowing in the two arms is equal, that is the resistance in the boiler-feed water circuit is the same as that in the standard coil adjusted by the sliding pointer, there is no deflection of the galvanometer needle. As soon as one current is different to the other, the needle moves, and the sliding pointer is adjusted to alter the resistance until there is no movement of the galvanometer finger. This sliding pointer moves over a graduated scale which indicates the resistance at once, which is also that in the boiler-feed water, and this resistance is proportional to the amount of alkalinity, or acidity in the water. The construction of the cell containing the boiler-feed water is most ingenious and unusual. One of the electrodes is hydrogen gas and the other calomel, both being in porous pots. A hydrogen cylinder holding 100 cubic feet of gas is used, and the gas is slowly bubbled round a platinum gauze disc. The calomel electrode is so arranged that the porous pot has maintained in it a constant circulation of 0.75 per cent. solution of potassium chloride, so that the feed water does not diffuse into the electrode. The feed water flowing through the cell is filtered, so that the platinum gauze hydrogen electrode is not affected, this being inserted in the side of the porous pot. The relationship between the alkalinity of the boiler-feed water and the voltage is shown in a series of curves, and it is a particular advantage of this method, that the greatest sensitiveness is shown round the neutral point, and the meter is extraordinarily sensitive to small changes in acidity or alkalinity. Thus, when absolutely neutral, the resistance between the electrodes is 0.75 volt, and traces of acid reduce the voltage at once, whilst alkali increases it.

SCIENCE

Conducted by A. H. HAVER, M.I.N.A. & K. S. DICKINSON, F.C.S.

THIS SECTION DEALS WITH THE APPLICATION OF SCIENCE TO INDUSTRY AND PARTICULARLY DEALS WITH APPLIED CHEMISTRY

The Paraffins

Mr. K. S. Dickinson, F.C.S., in his own inimitable way, explains in simple language the Paraffin Group of Organic Products.

In the course of conversation with a non-technical friend a few days ago, it fell to our lot to essay the explanation of the Paraffin Group of Organic Products. The friend in question appeared to find the subject sufficiently interesting to cause him to lose a material amount of his night's rest, and the thought has remained with us since that what interested him might very conceivably be of interest to our readers in INDUSTRIAL INDIA.

We will therefore, in the next few columns, attempt to give an account, in simple language, of this most important group of substances, many of which are in daily use in every country in the world.

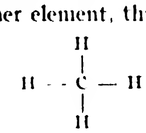
The technical chemist would define the paraffins as "A homologous series of saturated hydrocarbons, aliphatic in nature, and of the general formula C_nH_{2n+2}." Such a definition is hardly suited to the general thirster after knowledge, and it therefore requires elucidation. This may be done in a few words. A "homologous series" is a series of compounds, wherein each member, as one ascends, is greater than its predecessor, by the amount of one carbon, and two hydrogen, radicles. Thus the substances

C_2H_6
C_3H_8
C_4H_{10}

constitute a homologous series.

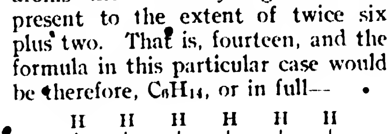
A saturated hydrocarbon is a hydrocarbon compound where all the "bonds" are fully occupied and attached to certain elements, and are therefore not available for attachment to other elements, unless they be first detached from those elements already in the molecule.

Thus, for example, the simplest hydrocarbon, Methane, is a saturated hydrocarbon, because all the bonds of the carbon are in combination with another element, thus :—

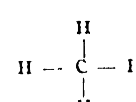


"Aliphatic in nature." In other words, fatty in nature. Not necessarily greasy, but "fatty" in the scientific acceptance of that term.

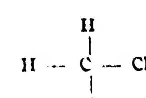
And finally, "of the general formula C_nH_{2n+2}." These general formulæ are of great use to the serious student of organic chemistry. By their means, he is enabled to hold in mind numerous separate and distinct series of compounds which would otherwise be a frequent source of trouble and confusion to him. The easiest explanation to offer of the meaning of the general formula would be to say "let *n* equal any number." Then the equation explains itself. For if the carbon element be present to the extent of, say, six atoms then the hydrogen will be present to the extent of twice six plus two. That is, fourteen, and the formula in this particular case would be therefore, C_6H_{14}, or in full—



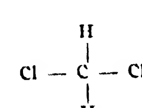
So much, then, in introduction of the compounds of the paraffin series. The name of the series, paraffin, is derived from what is probably the most noteworthy feature of the whole of the members of it. It came from Para=Little, Affinitas=Affinity, and is indicative of the fact that the whole class shows the most remarkable indifference to chemical reagents. They may be distilled with dehydrating agents, oxidising agents, acids, alkalies, almost anything in fact without showing the least evidence of change. The elements of the halogen series are the only ones of great importance that are able to affect the paraffins, and these, suitably employed, are able to convert the paraffins into a series of "substitution compounds," some of which are of very great commercial importance. Chlorine, for example, added to the simple paraffin Methane, CH_4, will yield four different and distinct compounds according to the length of time during which reaction has been allowed to occur. These substances are most graphically shown by means of their picture formulæ, thus :—



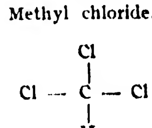
Methane.



Mono-chloro-methane or Methyl chloride.

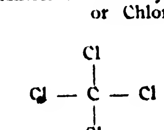


Dichloromethane or Methene Dichloride



Trichloromethane or Methenyl trichloride or Chloroform.

and



Tetrachloro-methane, or Carbon Tetrachloride.

Iodine and Bromine also form similar compounds. The curious fact, however, is that whilst Chlorine acts best in the presence of strong sunlight, or of the high powered electrical ultra-violet rays, Bromine and Iodine appear to show their affinity most strongly in the presence of heat.

From what we have already said anent the paraffins, the reader will understand that these substances may be tabulated in order. The more important members of the series so shown, here follows :—

Methane, CH_4.
Ethane, C_2H_6.
Propane, C_3H_8.
Butane, C_4H_{10}.
Pentane, C_5H_{12}.
Sextane, C_6H_{14}.
Decane, $C_{10}H_{22}$.
Quindecane, $C_{15}H_{32}$.
Vigintane, $C_{20}H_{42}$.
Trigintane, $C_{30}H_{62}$.

Moreover, a careful study of the formulae attached to each member of the series will show at once why the series is called a homologous one, each member increasing upon its predecessor by the extent of CH_2.

The first members of the series are gaseous, and found in widely varying places in the earth. As Marsh Gas, Methane is frequently met with in boggy places, both in temperate and tropical climes, whilst as Fire Damp it constitutes one of the great perils of the coal-getter's life. The honour of its discovery must be accorded to John Dalton, a Manchester chemist, who collected it, by the proxy of numerous Manchester ragamuffins, from the marshes of Fallowfield, where now abide some thousands of the clerks and merchants of that busy "Cottonopolis." The marshes have long since ceased to exist, but Methane, the simplest of all organic substances remains, the first compound to which practically every chemistry student is introduced when he takes up his organic course.

With Ethane we have little to do. Many important substances may be regarded as derivatives of this two-carbon paraffin, but except that it is a gas, colourless, tasteless, and inflammable, much like its homologue Methane, there is nothing about it to provide much food for examination and speculation.

When we get up to about the five-carbon member of the series we began to meet the most important members. C_5H_{12} is known to the technologist as Pentane, but to all the world it is familiar as petrol, or, in its state of highest purity and rectification, Petroleum Ether. As the source of energy that "makes the wheels go wound" (to quote our very old friends, Helen's Babies): it is known in every country in the world, and as a solvent of great importance, it is used by the thousands of gallons annually, in oil-works, dye-works, chemical plants, and by all sorts and conditions of men. Rare, however, is it that the non-technical user of it, in his car or his cleaning, realises that his volatile liquid is own brother to the Liquid Paraffin that he drinks as a laxative, or to the vaseline that he smeared on his plated metal to prevent it from rusting in the winter atmosphere. The liquid paraffin is a member of the same paraffin series as is petrol, but a higher member of the group. Its molecule contains fourteen or fifteen carbon atoms, and in bulk it consists of a mixture of paraffins of about the constitution $C_{15}H_{32}$, and $C_{16}H_{34}$. Colourless and clear as is petrol, yet much thicker, more viscous is a better term perhaps, and showing no tendency towards volatilisation if left exposed. It thus forms a very good half-way house, between petrol and vaseline, which is a solid, higher member still, but equally of the same paraffin series. The vaseline molecule consists of paraffins of about twenty or twenty-one carbon content, and when absolutely purified, is a clear white colour. Less pure, it usually exhibits a yellowish cast, varying several degrees according to several factors concerned in its isolation. Soft paraffin is the true commercial and pharmaceutical name for this commodity, but to the vast majority of the members of the lay public it is, and probably always will be, known as "Vaseline," because of the advertising activities of the Cheeseborough firm who manufacture that particular variety of soft paraffin. And after all, to give honour where honour is due, there is so far as our experience has carried us, no other soft paraffin to equal it, grade for grade, throughout the length and breadth of the manufacturing world.

It is all a question of fractional distillation. The Rock Oil, or Crude Paraffin Oil, bubbles up from the ground, or is drilled for, in various countries, the United States being of course the best known. This, we might have mentioned before, is a mixture of Decane Undecane, etc. $C_{10}H_{22}$, $C_{12}H_{24}$. If the natural mineral oil be subject to distillation, as the heats are applied, then the various fractions will be obtained, and by redistillation isolated in a high state of purity. Metallic substances held in solution are precipitated by various means, Sulphuretted Hydrogen being a common method. Redistillation frees the paraffin from any sulphur remaining in suspension. As to the commercial treatment of the paraffins, it is quite an impossibility to attempt its delineation in the bounds of this paper. The industry employs many thousands of hands, it involves the outlay of millions of pounds in capital, and finds an outlet for some of the cleverest chemists and engineers in the modern world. The uses of all the paraffins are so many, so varied, so fundamentally important, that they also ought to have at least the honour of an article to themselves. From soap making to ship-building, from cold-cream to cattle-farming, the paraffins have a place that it would be difficult to supplant, even were one able to provide an efficient substitute. We have in the paraffins a series of cheap, and therefore all the more valuable, hydrocarbons which have made, perhaps more than any other single group of substances, the possibilities of the Nineteenth Century become the most tremendous realities of the Twentieth Century. How long the natural supplies will hold out is a matter that appears to be open to much discussion. One week we read that someone estimates twenty years, the next week we see that there is an ample supply for the next ten generations. Then we hear of new wells being sunk here, there, and everywhere, with the most happy results. The following month we are told that those wells proved to be entirely valueless and that the oil obtained from them hardly paid for the sinking of the shaft. So, as with the various mines of various precious minerals up and down the earth, we must continue to take what we can get, thankful for each day's yield as it comes, and ever on the *qui vive* for the new deposits that shall help us eke out our little store, or for the new discoveries that shall make it a matter of indifference to us, whether our supplies peter out, even on that selfsame night. "We know not what awaits us," and we can but go on, from day to day, working, waiting, honestly doing the best that in us lays, knowing that after all, and through all,

"God is His own interpreter
And He will make it plain."

Transport in Japan

IN no country in the world has inland transport been so difficult as in Japan. Nowhere else have the difficulties been so successfully encountered. Few of the arts of the engineer have been left untried in coping with the manifold obstacles opposed by nature to the transport of man and his merchandise. One finds an astonishing variety in methods of transport, due first to the peculiar and varied physical features of the country, and next to the patience and industriousness of the Japanese, who, with a determination to wrest from nature the maximum of her resources, have displayed not a little ingenuity in devising varied means of transport suited to the different parts and features of the country. It cannot, therefore, but be most instructive to know how Japan has been able to meet the difficulties of her inland transport, so as to fit herself for the great strides she has recently taken in her industrial advance.

Physical Features

It will not be out of place here to give an idea of the kinds of obstacles that had to be surmounted, due more or less, as has been already mentioned, to the varied physical aspects of the country. This may also help us to properly appreciate the success which the Japanese have been able to achieve. In the case of Japan, in the words of a writer who can speak with a first-hand knowledge of the subject," Savage grandeur and appalling evidences of destruction alternate with scenes of almost heavenly beauty." More than three-fourths of the land is composed of mountains and hills, and many of these rise to a height of 10,000 ft. and over. Inflated mountain torrents, which swell from a mere shallow stream to roaring floods, cause much damage, dealing death and destruction far and wide. Heavy snowfalls and avalanches, which occur so frequently on the west coast and further north, inflict great damage on the coastal railway lines. There are in some parts, villages, smitten in summer with a scorching sun, and in mid-winter lying entirely buried in snow.

More disturbing factors are found in the violence of volcanic eruptions. Earthquake shocks are very common, and wreck even solid iron bridges, just as if they were merely made of match-wood. After the occurrence of an earthquake, it is common to find roads broken and abruptly ended in precipices. Then there are the mighty and destructive tidal waves, and frequent typhoons of great violence. In some parts again, a river bed is sometimes raised so high above the flat strip of shoreward-land, owing to the amount of sand and stones of all sizes washed down from the adjacent hills, that the railway track has compulsorily to burrow underneath it, through a tunnel. Sometimes, as in a precipitous valley, the line can rise only by complete spirals driven through the solid rock, where a height of 170 feet can be gained at the cost of over a mile of tunnelling. In short, it will be found that the task of furnishing means of transport and maintaining them in a reasonable order, is a task calling for intelligence, skill, and patience of no common kind.

Vehicles of Transport

The vehicles of transport vary according to the nature of the locality. In the higher mountain regions, the pack-horse or bullock is not available, and all loads have to be carried by man or woman, while in the lower hills, a two-wheeled hand-cart, the *ni-guruma* as the Japanese call it, is found in common use, hauled by sturdy coolies. The *kago*, a light form of sedan-chair made of bamboo, is generally in use for ladies and invalids. But the most common and well-known of the hand-drawn vehicles is the *jinrikisha*.

Among animal-drawn vehicles, is the *basha*, a popular four-wheeled stage-coach, drawn by one usually weedy horse. A slight variation from this is the one-horse tram.

Automobiles both for private and public use, are getting popular day by day. In larger cities, taxicabs are usual, while in some parts of the interior, small motor-omnibuses ply for hire. Pleasure cars for touring purposes are being employed between the larger cities and famous resorts.

Roads

In spite of the varied difficulties connected with road-construction, Japan is well provided with highways, some of which have come down from very ancient times. The most famous is one known as the Tokaido, which runs between Kyoto and Tokyo. All roads are divided into five classes : national, prefectural, district, city, town and village. The first two are under the control of the Home Minister ; the others are in the charge of the local governers or magistrates. The former consist of the highways leading from Tokyo to the shrine of the Imperial ancestors at Ise, to the head-quarters of Army divisions, to naval stations, to prefectural offices, and to the chief "open" ports. The latter consist of minor ramifications of the former. The construction and condition of the roads vary considerably owing to the peculiar climate, and the lack of suitable material. There is comparatively little macadamizing. Much of the soil is volcanic, and the thick dust in dry weather is apt to be transformed into a slough of despond after heavy rains. It is only in the granite districts of Central Japan, that the best roads are found, while those on the alluvial plains near the sea-coast offer a painful contrast to them.

Bridges

As a result of the numerous rivers, torrents and streams, bridges are a typical part of public works, and show a great variety in construction. The longest railway bridges are on the Tokaido line—over the Tenryu River (1322 yards), and over the Oi River (1111 yards), respectively. The foundation work of the bridges usually takes the form of cylindrical brick wells, with steel girders. Near Toffori, on the west coast, a steel trestle bridge, 1020 feet long, spans a gorge 130 feet in depth. In some of the mountain regions, a common type is the suspension bridge of wire rope, with a foot-board of wood and a low hand-rail. The *Kago-Watashi* bridge consists of a rough cradle slung on a rope of wire or creeper, along which the traveller hauls himself by a series of frog-like jerks, with the imminent

possibility of finding himself suddenly hanging, suspended in mid-air or plunged in a roaring torrent. The commonest form of bridge for general purposes is, however, the neat, solid structure of wood in use from time immemorial in all parts of Japan.

Waterways

Japan has got few navigable rivers. In most cases their courses are short, their beds are narrow, and their currents are swift. On some of these rivers, long, flat-bottomed boats, laden with merchandise, pass the "rapids," a distance of 50 to 90 miles, on their way to the sea, in five to ten hours, while the return journey takes upward of a week or a fortnight. Steam launches are in use only on the lower reaches of the largest rivers, such as the Yodo, the Shinana and the Tone. One of the most useful rivers is the Yoshino, in Shikoku, in the northern part of Tokushima perfecture; the part of the country is ill supplied with railways and has mainly to depend upon this river for transport. Altogether the rivers of Japan, for the purpose of inland transport, are of little importance or interest.

The Railways

The total mileage of railways in Japan is 7,900 miles, of which 6,200 are owned by the Government, and 1,700 by private companies. Since the first railway in Japan was built in 1872, progress has been steady and consistent, in spite of the difficult geographical character of the country. The chief railway system of Japan practically consists of one long trunk line in the main island, which with its virtual continuations in Hokkaido in the north and in Kinshin in the south, extends in one direction for 2,000 miles. The fastest speed developed is on the Tokyo-Yokohama section, the 18 miles being covered in 28 minutes. The guage of the railways is narrow, 3 ft. 6 in., and, except on the Tokkaido line, is for the most part single track. The worst gradients are in the Usui Pass, on the Tokyo-Nagana line, for which the Abt system was adopted. The gradient there is 1 in 15, and there are 26 tunnels, with an aggregate length of 14,645 ft. In this section steam locomotives are replaced by electric locomotives of greater hauling power. The longest tunnel is that at Sesago, on the Tokyo-Shiogiri section of the Central line, which is 15,260 ft. in length and took six years to build.

Reviews

David Bridge & Co. Limited, Castleton, Manchester.

We have received from the above firm a set of their recent catalogues, dealing with some of their leading manufactures including the following: scutching machinery, horizontal baling presses, copra dryers, friction clutches, and rubber machinery.

The catalogue dealing with scutching machinery is more properly described as a short treatise on cordage fibres, and includes an interesting description of their origin, treatment and use by Frederic A. G. Pape, F.R.H.S., F.R.G.S., dealing with fibres from different parts of the world.

The catalogue on horizontal baling presses gives full information regarding the Cummins horizontal cotton baling press, which is capable of an output of 50 bales an hour of 400 pounds, and one of its leading features is the fact that loose cotton may simply be thrown into it without any force whatever, so that four coolies can easily fill it in five seconds.

The pamphlet on Copra dryers is again in the nature of a treatise, and contains very full and detailed information regarding mechanical processes of drying Copra and Cacao.

The catalogues dealing with friction clutches made by this firm call for little comment, as they are almost universily well-known. One interesting feature, however, of the catalogue, is the fact that a line plan is given on the opposite page to each photograph, which shows in a very clear manner the detailed application of the clutch for various methods of power transmission.

The catalogues dealing with rubber machinery cover every department of this industry and describe very fully the various machines used in the process of converting raw rubber into articles of commerce; including: calendars, mixing machines, hydraulic presses, vulcanizing pans, solution mixers, moulds, dryers, etc.

We hope in a future issue to give some details of this firm's rubber machinery, when we deal in Industrial India with the subject of "Rubber Manufacture."

Any of these catalogues are, of course, available to our readers on application direct to Messrs. David Bridge & Co., Castleton Iron Works, Castleton, Manchester.

"Coal Saving by Modern Methods of Steam Generation."

We have received from Mr. David Brownlie of 4, Grangethorpe Drive, Burnage, Manchester, copy of a reprint of a series of articles entitled "Coal Saving by Modern Methods of Steam Generation," from "The Textile Manufacturer" of August 1921, to March 1922. This pamphlet is now available for general distribution, and may be obtained from Mr. Brownlie, at the above address, for the nominal price of 2/6 per copy. Mr. Brownlie is the well known authority on boiler house efficiency, and his complete analysis of the results of the working of sixty-five boiler plants, recorded in this pamphlet, should be in the hands of every steam user. These results were obtained from boiler plants in the dyeing, bleaching, calico printing and finishing industries, representing 217 boilers with an annual coal bill of 275,637 tons.

The exact figures for each of the sixty-five plants are given in detail, and represent many years work. These show that the average net working efficiency is only 61.46 per cent., while individual plants vary from 80.09 per cent. to 40.06 per cent. The figures for these particular industries are typical of all industries, and show the enormous fuel economy which can be obtained by adopting up-to-date methods of steam generating.

Mr. Brownlie goes very fully into the details of each test, showing exactly the working conditions under which the figures were obtained, and the detailed figures given in the tables, showing the results of each boiler plant test, are extremely intructive to the steam user, and show exactly the conditions of working at each point in the boiler house, giving full details as regards temperatures, fuel analysis, CO_2 contents, and so forth, and with such information the steam user should be able to make very useful comparisons with his own boiler house plant.

INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

Volume II | SEPTEMBER, 1922 | Number 2

BETWEEN OURSELVES

Test Results at Dalmarnock

SOME interesting figures relating to the test results at the new Dalmarnock Power Station (Glasgow), were given by Mr. R. B. Mitchell in a recent paper read at the Glasgow summer meeting of the Institution of Electrical Engineers.

Taking first the boiler plant, as offering the most possibilities of economy by the use of up-to-date methods, the steam pressure is 275 lb. gauge, and the temperature of the superheated steam 700 deg. F., whilst the coal is not of good quality, averaging 10,800 B.Th.U. The feed water averages 141 deg. F. going into the economisers, and 274 deg. F. going into the boilers, whilst the flue gases are 630 deg. F. entering the economiser and 400 deg. F. leaving the plant. The average figures for CO_2 is 10%, and the draught is 0.3 ins. W.G. over the fires, 1.5 ins. W.G. at the dampers, and 2.5 ins. W.G. at the fan inlet. The feed water is composed of 3.85% make-up and the actual lbs. of water evaporated per lb. of coal is 6.5 lb. Also, the total steam or power used for stokers, fans, boiler feed pumps, and other purposes auxiliary to the production of steam, is 1.68% of the total steam production. The efficiency of the plant is given as 74%, being 56.94% for the boiler, 9.23% for the super-heater, and 7.86% for the economiser. It is refreshing to be able to study the actual honest figures obtained in practice from day to day on a power station, and most engineers are getting rather tired of the 82½–85% efficiency generally given. The figures of 74% efficiency at present being obtained at Dalmarnock are, however, considerably higher than most power stations. The author states, and we quite agree with him, that by increased attention and experience with the plant it will be possible to get up eventually to about 80% efficiency, although a defect in the design of the portion of the boiler plant already erected is that no provision has been allowed for air heating. The most determined attempts have evidently been made to ensure that a proper scientific supervision of the working of the plant is maintained. The amount of coal supplied separately to each boiler is given by automatic coal weighing machines, and a CO_2 recorder is also fitted to every boiler, whilst there is in addition an elaborate installation of steam meters, pyrometers, and draught gauges. The performance of the turbo-generator is also under continuous observation, the steam consumption being measured by a "Lea" recorder in the condensate circuit The station has been running during the past few months at about 34% load factor, because of the great trade depression in Glasgow, but the following most interesting figures are given as to the cost of production, expressed as pence per unit of electricity, for the month of April last :-

OPERATION.

Coal	0.1752	pence.
Coal handling ...	0.0060	,,
Ash handling	0.0082	,,
Water	0.0009	,,
Oil and stores ...	0.0040	,,
Shift wages and salaries	0.0202	,,

MAINTENANCE AND REPAIRS.

Building, wages ...	0.0057	,,
Buildings, materials ...	0.0007	,,
Engine room, wages ...	0.0082	,,
Engine-room, materials	0.0061	,,
Boiler-room, wages ...	0.0132	,,
Boiler-room, materials	0.0056	,,
On cost charges ...	0.0095	,,
Total ...	0.2635	

The Characteristics of a good Lubricating Oil

The necessity of good lubricating oil does not require to be emphasised, although what constitutes exactly such an oil is a matter of opinion. In this connection the recent specification of the United States Government will be of great interest. This specification refers to a good grade of petroleum oil, without admixture of fatty oils, resins, or soaps, suitable for steam engines and turbines, air compressors and internal combustion engines other than petrol and "Diesel" engines. This quality of oil is divided into five grades, extra light, light, medium, heavy, and extra heavy. The flash point specified for these grades is 315 deg., 325 deg., 335 deg., 345 deg., and 355 deg. F. respectively, whilst the viscosity at 100 deg. F. in the standard viscometer is to be 140-160, 175-210, 275-310, 470-410, and 470-520 seconds. As regards general chemical properties, the acidity is not to exceed the equivalent of 0.05 milligrammes of caustic potash per 1 gramme of oil, whilst also a clean copper plate must not be discoloured when immersed in the oil at 60-70 deg. F. for 24 hours. As regards emulsifying properties, the oil has to separate in 10 minutes from an emulsion with (1) distilled water, (2) 1% salt solution, and (3) normal caustic soda solution. Finally, the carbon residue must not exceed 0.1%, 0.2%, 0.3%, 0.4%, and 0.6% respectively.

* * *

Indian Paintings

On May 26th Viscount Peel, the Secretary of State for India, presided over a lecture to the Royal Society of Arts, on "Indian Painting and Mohammedan Culture," by Sir Thomas Arnold,

Professor of Arabic at the School of Oriental Studies. This was the third annual lecture in memory of Sir George Birdwood, and Sir Thomas Arnold took as his subject Indian paintings as a neglected source of enlightenment on the social aspects of Mohammedan rule in India. His purpose was, by reference to selected Indian pictures, to suggest directions in which research into Mohammedan history might be pursued, and to throw out suggestions as to the manner in which pictures might be used as aids to historical research.

Indian paintings are numerous in the museums and private collections of this country. Taking first of all religious paintings, Sir Thomas threw on the screen pictures illustrating the reverence for saints, the blind submission of religious devotees, religious ecstasies and ceremonial dancing. An interesting picture of a Mohammedan prince, sitting at the feet of a well-known Hindu priest, showed that concourse between Islam and Hinduism was not unknown, and suggested that the necessity of establishing a *modus vivendi* between the two faiths was early apparent.

Painting was a courtly art, and a study of pictures throws light on many problems of the Mohammedan Court, on manners and on dress. Curiously enough the Mohammedan skirt, worn by men, survived longest in the Hindu courts, but before its disappearance from the Mogul courts it underwent many modifications. In the 18th century it became so long that it swept the ground, and this illustrates the depths of effeminacy to which the ruling race had fallen.

Pictures again show the important place occupied by dancing. In the fashionable portraits of the 18th Century, the sitters are always painted watching a dance, and no longer standing alone, or leaning on a sword as was the more virile fashion of an earlier age.

The absorption of the later Mogul rulers in drinking, and the preparation of food in the palaces, were also illustrated by contemporary pictures.

Sir Thomas drew attention to the fact that there was a certain amount of negative evidence to be drawn from pictures. When the Mogul Empire was breaking up, and the raids of Mahrattas were creating chaos and confusion, no longer did the painter paint what might be termed court subjects, but he turned to other and happier times, or to romantic themes and fairy stories.

Lord Peel, in proposing a vote of thanks to Sir Thomas Arnold, expressed a hope that as a result of the lecture many students would be inspired to write much needed monographs on the domestic life of Mohammedan society of the 17th and 18th centuries.

* * *

The Heat Losses of Steam Pipes

The Mellon Institute of the University of Pittsburgh, U.S.A., has been carrying out a valuable series of experiments to determine the amount of heat lost by a bare steam pipe exposed to the air. They point out that most of the previous work in this direction has been undertaken with one size of pipe only, and at comparatively low steam pressure, and accordingly they have devoted particular attention to the results of the use of high steam pressures and superheat, using pipes of different sizes, 1 in., 3 in., and 10 ins. The temperature range of the steam used in the pipes went up to 500 deg. F. difference, and in the case of the 1 in. pipes as high as 700 deg. F. difference. The results are given in the form of a mass of figures, which unfortunately it is impossible to reproduce because of lack of space.

Taking, however, as typical a 10 in. bare steam pipe at 160 lb. pressure, the amount of coal lost per month of 30 days per 100 lineal feet of pipe, working 24 hours a day, is 20,910 lbs., corresponding to 8.805 B.Th.U. per lineal foot per 1 deg. F. difference in temperature. In this calculation the coal used in the boiler plant is taken as 13,000 B.Th.U. per lb., the boiler plant efficiency as 70%, and the temperature of the air as 70 deg.F. Taking the same sized steam, pipe, 10 in.. the effect of change of pressure in the pipe, as regards the increased amount of heat lost, is illustrated by the fact that at 10 lb. pressure the figure of coal lost for the month on 100 lineal feet of pipe as before is 8,820 lb., corresponding to 6.584 B.Th.U. per lineal foot per 1 deg. F. difference, at 80 lbs. pressure the figures are 16,100 lbs. coal, and 8.010 B.Th.U., at 120 lbs. they equal 18,690 lbs. coal and 8.400 B.Th.U. and at 200 lbs. pressure are 23,100 lb., coal and 9.150 B.Th.U.

As regards the difference due to varying sizes of steam pipe, taking 160 lbs. steam pressure, a 3 in. pipe—conditions as before—would lose 7,210 lb. of coal per month and 3.030 B.Th.U. per lineal foot per 1 deg. F. difference, a 6 in. pipe 13,120 lb. coal and 5.522 B.Th.U., an 8 in. pipe 16,940 lbs. coal and 7.125 B.Th.U., and a 12 in. pipe 24,700 lbs. coal and 10.40 B.Th.U. A very high class steam pipe covering, such as 85% magnesia or slag wool, will give about 92½-95½% efficiency, that is to say it will prevent 92½-95½% of the loss, so that for any given conditions the steam pipes can be measured up and the loss calculated. It should be noted, however, that most of the cheap and shoddy coverings used give nothing like these efficient figures after a few months in work, and probably 70-80% efficiency is a good average. The serious loss per annum caused by inferior coverings will, therefore, be obvious, and it can only be emphasised again that cheap and shoddy coverings are the worst possible investment. An interesting feature of the report is the attention drawn to a popular misconception as regards air space in coverings. The value of a good covering from the point of view of the prevention of heat loss consists in the air spaces or pockets imprisoned in the covering. These air spaces, however, must be very small and absolutely dead, so that no movement of the air is possible. Air is a perfect non-conductor only so long as it is not in motion. If a large air space of say ½ in. is left round the pipe, the result is practically nil, because the mass of air inside is in motion, and conveys the heat by convection to the outer portion of the covering, so that the only result is to increase the area of the pipe for heat loss.

British Railway Novelties

One of the leading British Railway Companies has recently completed its first electric locomotive for main line traction. This locomotive is capable of hauling a full size train at a speed of 65 miles per hour; and at its recent trails it completely fulfilled the exacting specifications, which had been placed before its designers. All the electrical and other equipment for this locomotive was designed and manufactured in Great Britain.

INDUSTRIES

Conducted by FRANK DAWSON.

THIS SECTION DEALS WITH THE GREAT BASIC INDUSTRIES OF INDIA. IN :: :: THE PRESENT ISSUE WE DEAL PARTICULARLY WITH EUCALYPTUS OIL :: ::

Installation of Extensive Gas Works Plant

for the Corporation of the City of Glasgow (II.)

(*Continued from page* 7.)

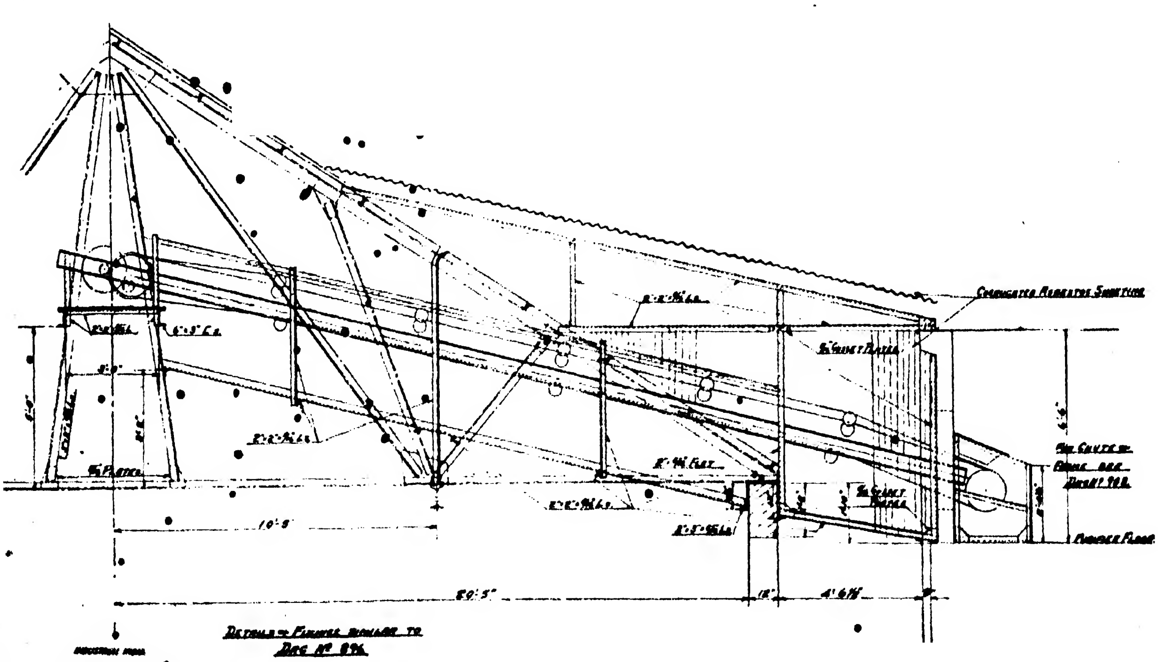
By BIRENDRA NATH DEY, B.Sc., A.M.Inst.C.E. etc. Consulting Engineer, 94-96 Kensington High Street, London, W.8.

(Director, International Engineers' Syndicate, and Economic Structures Co.)

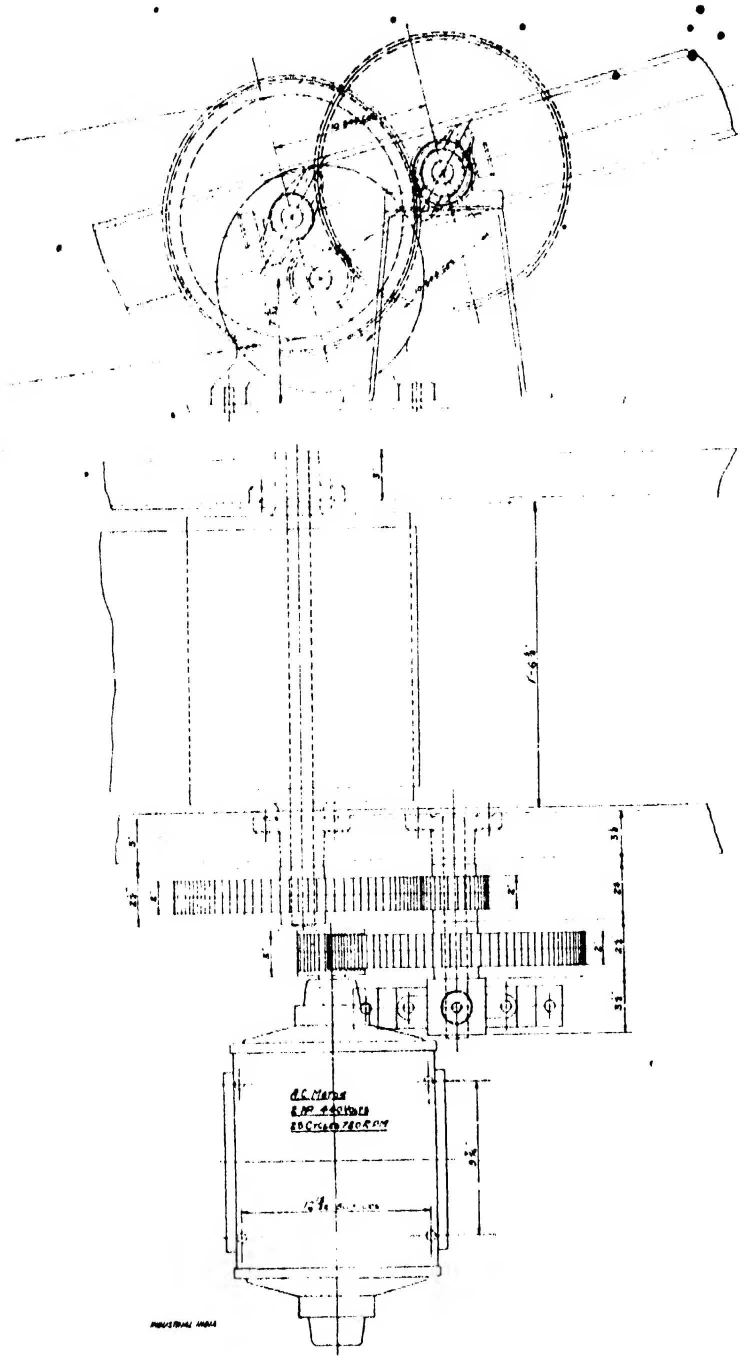
CONVEYORS rest on the revivifying floor at feed end, and are suspended from catchbox roof trusses at the other end. Four of the conveyors discharge into swivel chutes placed overhead at the centre of boxes. The fifth conveyor is a long-range one, and can be discharged into two secondary short conveyors which run normal to the former and towards the centre of the fifth and sixth catchbox. Conveyors are troughed belt type, with three roller idlers running on hollow shaft for grease lubrication. The return idlers are of parallel type mounted on hollow shafts. The driving arrangement consists of a douole train of spur gears driven by a 2 h.p. electric motor at discharge end. At the feed end sliding bearings are fixed, to which are attached long screws for taking up stretch in belt The belt is of special type and consists of rubber covered belt with stepped plies of canvas duck from six on the outer edge of the belt to three at centre. This allows the belt to conform to the contour of rollers easily and without permanent distortion of the fabric, also provides an extra thickness of rubber in the centre of belt where carrying capacity is greatest. A parallel gangway and roof allowing sufficient head room have been provided with each conveyor. The sides of the structure are sheeted. The girders are sufficiently strong to withstand vibration.

Purifier Covers

The Purifier Covers have been specially designed, as shown on accompanying drawing, with a view to strength combined with lightness, having a camber of four inches both



Details of Conveyor Arrangement



Conveyor Motor and Gearing

ways for draining off moisture. Four substantial lifting lugs are provided to receive the chain hooks of lifting apparatus.

The rubber jointing is, in the case of 44 covers, of patent steel threaded rubber lute, and in the case of the remainder of "Eclipse" rubber joint. In all cases the covers are secured to the holding-down bolts embedded in the ferro concrete box, by means of substantial holding-down plates joggled to allow full clearance.

The manufacture throughout has been of the best description, all plate edges planed, all holes drilled from the solid, pneumatic riveted and caulked, the angle curb being welded up complete. The covers have been made solely with the aid of machinery, no hammer marks whatever appearing on same.

Two covers on each box are provided with a special design of air valve, and each cover is provided with a thermometer pocket and test cock. Baffle plates are attached to underside of covers where inlet pipes occur.

Each cover, when complete, is tested with water for tightness before being placed in position, and the whole will be ultimately tested by air pressure.

General Arrangement of Gas Pipes

The boxes in the new plant are divided into four groups of four boxes with one catchbox to each. Each group is controlled by one eight way 24 in. Weeks centre valve. There are also two extra catchboxes provided for the two sets of purifier boxes, intended to be built later in continuation of purifier house. The catchboxes are of same design in all details as the purifiers, excepting that they have extra connection with the old plant and are thus available for use alternatively in conjunction with one set of either plant. The inlet main is connected to the centre valve through a 24 in. diameter Westwood & Wrights patent valve, straight flanged pipes, and one water valve placed adjacent to the centre valve. Four inlet and four outlet 24 in. diameter pipes, each with two 18 in. diameter branch tees form the connection between centre valve and the four purifier boxes. A 24 in. diameter main outlet pipe from centre valve through water valve and Wrights patent valve, takes the purified gas to the outlet main. The main outlet pipe from centre valve is branched off at an intermediate point to form an inlet to the catch box through two usual valves, and finally through two 18 in. diameter branch tees. The 20 in. diameter inlet from the old plant is connected to, and is in line with the inlet from the new purifiers. Outlet pipes from catch-boxes are connected through valves direct to the outlet main. The temperature of gas entering and leaving the centre valves can be noted from dial thermometers fixed in main inlet and outlet pipes adjacent to the valve.

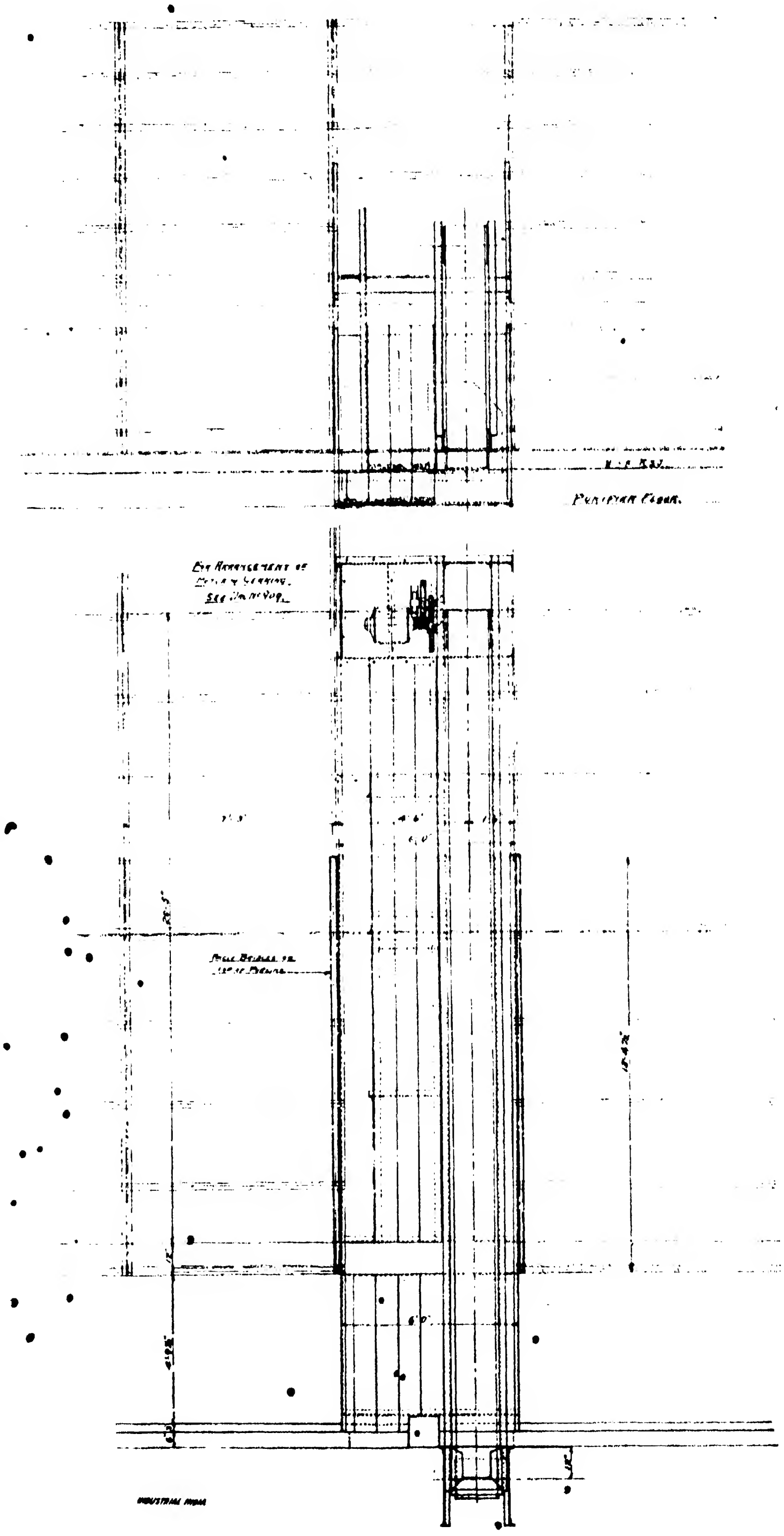
Gas Mains

Inlet main extends from east end of plant, 437 feet westward, and is placed at an average height of centre

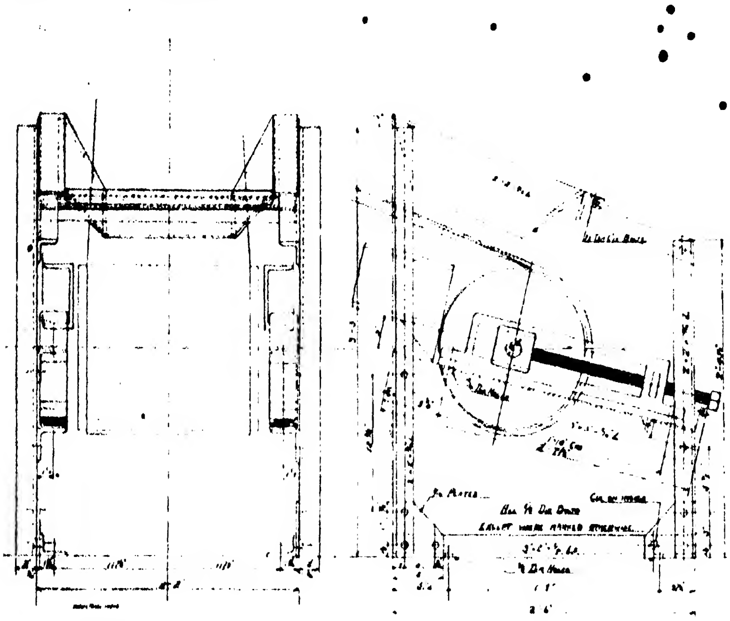
8 ft. 6 in. above ground, allowing about 7 ft. of head room at the lowest point. The pipe is reduced in size after each set of branch connections from 48 in. diameter to 42 in., 42 in. to 36 in., finally 36 in. to 30 in. diameter. Taper pieces between different sized pipes are constructed to keep the water run unbroken, that is, the bottom of all pipes in line. The main is laid to fall uniformly west to east, about 18 in. in the whole length, and drained at every tee branch piece with 2 in. diameter pipe. Six 24 in. branch tee pieces are included in the main for connections to the four Weeks centre valves in the purifiers and two valves to be installed later. The 24 in. diameter branches on the tees are cast eccentric to the centre line of the main to keep all the branch connections at same level, while the main is falling. This method allowed standard castings to be used in all branches. Manholes 24 in. diameter are provided at about 100 feet interval. Expansion joints are included in each long stretch of pipe, between two anchored points. The joints are Messrs. Glenfield & Kennedy's make, and are specially bored out to ensure sliding, also to allow more room for packing. The main is supported on half round L section hoops hinged to L section bars attached to the ferro-concrete cross beams under purifier floor at 20 feet interval. This arrangement allows portions of the main to swing to and fro in case of expansion and contraction. The east end section of the main outside the purifier house, rests on cast iron roller bearings supported on built-up steel stools. Straight pipes and tees are all cast flanges faced across and bored according to British Standard specifications. As a jointing material, paper millboard washers 1/8 in. thick soaked in French polish formed of shellac dissolved in wood naphtha and bolted up wet has been found satisfactory. Outlet main is precisely the same as the inlet main, excepting that it includes six extra 24 in. diameter branch tees to receive the catchbox outlet pipes.

Branch Pipes and Tee Pieces and Quarter Bends

These castings are all made to British Standard specification, quarter bends are provided with cleaning doors. At each rake in the branch pipes there is a socket and spigot lead joint.



Details of Conveyor arrangement



Conveyor Adjustment

When it is desired to lubricate the valve, the cone pin K, is removed, the recess forming an oil cup, which is connected to the grooves I in the face of the body of valve. Incidentally, this oil cup furnishes an excellent means of testing the absolute tightness of the valve.

A great advantage in this valve consists of the fact that the machined faces are always, protected against any corrosive action, the settlement of any grit, or deposition of tarry vesicles or other foreign matter, whether the valve is open or shut. Other advantages claimed are that the faces may be lubricated from outside, if desired; that there is no liability of the parts to stick or become unworkable; and that it is always reliable in all positions, and for all kinds of gases; further, it can be tested for tightness, whilst in position.

Valves

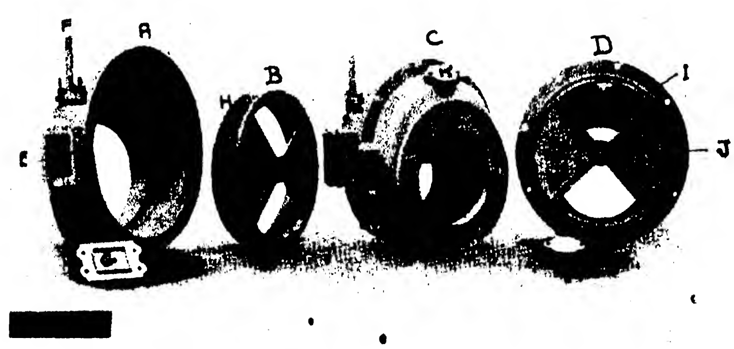
The control valves, 20 in. and 24 in. diameter, are of Messrs. Westwood & Wrights' Patent Type. These valves are especially suitable for purifier work, owing to their reliability for tightness under all conditions.

The general arrangement of the valve will be seen from the details shewn. In the body of the valve, A, E is the screw, and F the spindle, which operate the valve. H is a set of tangent teeth upon the movable disc B. D is the body of the valve, shewing the valve face, J being the centre pin upon which the movable disc rotates, while I is a groove cut in the valve face, by means of which the faced surfaces are lubricated if and when desired, by means of a lubricator K, shewn in the complete valve at C.

When the valve is being operated the movable disc B is kept pressed to the face by the coil spring, but just as the valve is closing a system of wedges or inclined planes come into operation, the faces being forced together, making a perfectly gas tight joint without relying upon springs or other means. When thus closed, the valve is perfectly gas tight.

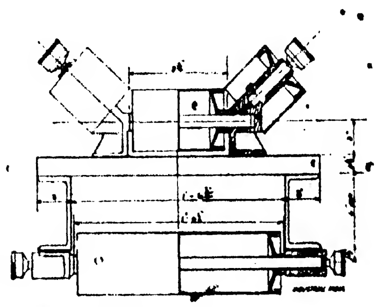
If required to stand high pressures, the parts are made rather stronger than is necessary for ordinary pressures.

In opening and closing the valve,



Westwood & Wright's Patent Control Valve

the movable disc B is moved through a quadrant of a circle by the powerful tangential screw E, working in the bevel teeth cast upon the rim of the



Conveyor Belt Rollers

faces; the valve spindle F, being turned to the right in opening, and the reverse in closing.

The valves are very carefully manufactured with castings free from all flaws or blow holes. The faces, after being turned in the lathe, are rubbed down on a face plate, thus ensuring a perfect joint. Each valve is carefully tested before despatch, and a record kept of same, test certificate being supplied upon application.

The valves are operated either by elongated spindles or bevel gearing, according to situation, as shewn on drawings. The spindles are carried through Handwheel columns, which include Westwood and Wrights' Patent Indicators, a valuable addition, shewing as they do at a glance, and from a distance, whether the valves are quite open or closed. All gears are of gunmetal, and all supporting brackets bushed with the same material.

Eucalyptus Oil

The following instructive article has been sent to us by one of our Indian readers, who makes some suggestion for putting the Eucalyptus industry on a more efficent basis.

History and Introduction

THE distillation of Eucalyptus Oil in the Nilgris dates as far back as 1860, when the first plantations were started by a few European settlers. Since then the Industry has been increasing in importance for various reasons, and a good market for the oil is on record. The particular genus *E. Globules* or the Blue gum is the variety found in abundance on the Nilgris. This is pre-eminently suitable for the distillation of the best Eucalyptus oil in the British Pharmacopoeia. Nevertheless a good deal of Australian oil is imported for consumption in this country. The following account, it is hoped will not only review the present position of the Industry in the Nilgris, but also indicate certain lines of future development.

The Distillation of Oil

The distillation of oil was first started on a small scale by a few European settlers about 50 years ago. At present a little more than 2,400 lbs. of oil per year is distilled and sold. The general rule has been that any man having a small Eucalyptus plantation of his own has erected a small distillery, using the leaves obtained from his own estate. At present there are five planters engaged in the Industry. In addition to this there is a small still producing 3 lbs. of oil a day, in the Goot Botanical Gardens, Ootacamend. These firms obtain the major portion of their leaves from private estates, and the rest from Goot plantations. The Ootacamemd oil is not generally re-distilled, except by one of the firms (Manager, Mr. Brown of the Felixstowe Laboratory). Others who tried re-distillation have not had much success owing to the faulty type of plant employed, which resulted in a loss of more than half the oil. The best form of still is used in Ootacamemd, and is illustrated on page 60.

Leaf Supply and Cost of Production

The chief consideration in the way of a greater expansion of the Industry is the question of leaf supply. In Australia the distillation of the oil is a great success on account of the maintenance of a constant leaf supply by adopting the "lopping" system. This system has been found impracticable on the Nilgris. The only other possibility is the starting of special plantations on short rotation for the purpose of a regular supply; the fuel being of secondary importance. The quantity of leaf that can be made available at present can be found by a simple calculation. Taking roughly 2,400 lbs. of oil as the annual output from Ootacamemd, and 8 per cent. as the average yield of oil, the total quantity of leaves consumed by different distillers come to about 1,300 tons per year. The total acreage under Eucalyptus is 1,914 acres. The total yield, calculated according to the exports carried out by the Forest Department is five tons per acre. So that, if all the trees are felled, there should be available 9,570 tons of leaves. As a matter of fact, however, the forest revenues per annum for Eucalyptus trees removed is only about Rs. 200. Taking 8 pies per 200 lbs. of leaves that the distillers pay for them, it seems that out of the 1,300 tons used only about 450 tons are obtained from Govt. felling acres, and 850 tons from privately owned plantations. Since lopping cannot be adopted with advantage attempts must be made to start fresh plantations for the supply of leaves.

The cost of production is as follows:

	Rs.	As.	Ps.
Cost of leaves 200 lbs. ...	0	0	8
Cost of collection	0	6	0
Carriage	0	8	0
Interest on actual outlay ...	0	4	4
Total Re. ...	1	3	0

The yield per acre 200 lbs. is 27⅝ oz. The sale price for this is Rs. 2. So there is a profit of about 12 as. per 200 lbs. of leaves. This is the general cost of production. The following is the cost of production by Mr. Brown, who was kind enough to place the following figures at the writer's disposal :—

Cost of production—11⅛ lbs. (Without Transport of leaves)	10As.
Transport of leaves	2As. 3Ps.
Cost of bottles, minor expenses, etc....	3As. 9Ps.
Total cost for 11⅛ lbs. ...	Re.1-0

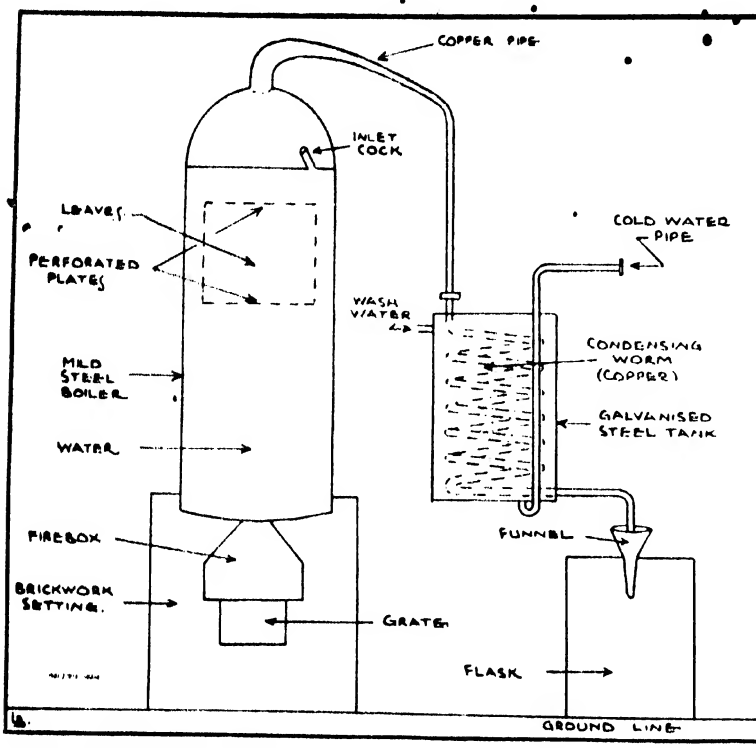
The oil is usually sold at from Re. 1/10 to Rs. 2.

The profit per bottle of 1⅛ lbs. is 10 to 12 as.

The Nilgris distillers get a profit of 6 to 8 As. per lb. The wholesale price at which Australian oil is imported into India is about Re. 1 per lb., a price which the Nilgiri oil fetches. The quotation for Eucalyptus oil in London is Re. 1-4 to Re. 1-5. The cost of transport from an Indian port to London is not more than 1 to 2 As. per lb. of oil. It is therefore, safe to take the lowest estimate of Re. 1 per lb. as the maximum sale price of the Nilgris oil, in order to calculate the commercial possibility of the Industry. In order to sell larger quantities of oil to the wholesale dealers, and in view of the extremely low prices of imported Australian oil, it will be eventually necessary for the Nilgris distiller to reduce the cost of production to such an extent as to be able to sell the oil at a wholesale price of As. 15 per lb. at the distillery, or at Re. 1 per lb. including the cost of packing, tins, etc., at Calcutta or Bombay.

Future Prospects—Developments of the Industry on More Profitable Lines

In spite of so many favourable circumstances, the fact stands, that a good deal of Hashaban is still imported into this country, showing



Diagrammatic arrangement of Still

that the Industry has not been fully exploited. In this connection a series of experiments carried out by Mr. Puran Singh, Forest Chemist, Research Institute, Dehra Dun, are found extremely interesting. These experiments were carried out with a view to work out the various factors that will contribute to the economy of the Industry.

Semi-commercial distillations were carried out on the spot, and as the result of a series of experiments, he came to the conclusion that much depended upon the nature of the leaves. While the best yield of the ordinary Nilgris distiller is 1.4 per cent. of oil calculated on the weight of the dry leaves, by using the mature leaves drawn from trees planted so late as 1873, the yield obtained was 2.28 per cent. Thus the distillation of such mature leaves is recommended as a first step. The initial outlay of capital on mechanical contrivances calculated to reduce the cost of transport of leaves is recommended in preference to making arrangements from time to time and dealing with un-skilled and half-hearted labour obtainable on the Nilgris. This refers to details of organization, which an enterprising manufacturer can easily overcome, and thus secure permanent reduction of his recurring charges of transport. The design of the still recommended for adoption is of iron lined with copper. A catch still will serve the purpose of holding back impurities, and the very heavy sesqui, thus giving even in the first distillation a very good oil and avoiding re-distillation. The leaf supply ought to be increased by starting special plantations on a very short rotation, the resulting fuel being of secondary importance. To make it a profitable industry, it must be worked on a sufficiently large scale (about 2 tons of leaves per day).

Working Costs

On the above lines, taking a factory of two stills each with a capacity of one ton of dried leaves to be worked alternately by a 30 N.H.P. boiler, the following initial costs will have to be taken into account.

OUTLAY.

	Rs.
Boiler and accessories ...	8,000
Two iron stills, copper lined	6,000
Sheds, etc.	7,000
Other charges	4,000
Total ...	25,000

	Rs.
Interest at 6% on Rs. 25,000 at Rs. 125 per month ...	1,500
Depreciation at 10% on plant	1,400
Depreciation on buildings sheds, etc., at 10% per year or R.58-5-4 per month	700

Such a factory can easily deal with 4 tons of leaves per day, 100 tons per month of 25 working days. This should produce about 3,300 lbs. of oil per month taking the yield at 1.39 per cent. This on 3,300 lbs. of oil, the depreciation and interest charges come to Rs. 299-15-6, or about 1 As. 7 Ps. per lb.

The supervision charges may be put down thus :—

	Rs. per month.
Manager and engineer ...	200
Two drivers a maishis at R.30	60
Two firemen at R.15 ...	30
24 Coolies at R.10	240
Clerk and time-keeper ...	40
Miscellaneous	30
Total ...	Rs. 600

This on 3,300 lbs. works out about 3 As. per lb. The royalty on the leaves paid by the distillers is quite the right figures of 5 pies per lb. of oil.

The total cost of production at present comes to about 10 As. 8 Ps. per lb. of oil, but as shown above, by a more efficient organisation of collection and transport, the figure could be brought down as follows :—

	Rs.	As.	Ps.
Cost of leaves (Royalty) ...	0	0	5
Cost of lopping and collection	0	1	4
Cost of transport for a distance of five miles ...	0	1	8
Packing	0	0	3
Fuel	0	0	6
Supervision...	0	3	0
Interest and depreciation	0	1	5
Total ...	0	8	7

In comparing this figure with those given by the Nilgris distillers (0.-10.-8. ps. per lb.), account has not been taken of interest on capital, depreciation, supervision charges, which might be put down at about 4 As. Thus the total cost will come up to about 15 As. for the Nilgris distiller. If the sale price of the oil went as low as 11 As. per lb. at the factory, a net profit of 2¼ As. per lb. could be secured. If it is sold at Re. 1 at Bombay, or Calcutta, it will fetch a net profit of 7 As. 5 Pies per lb., also it will probably capture the foreign markets and thus stand a fair chance of competition with the Australian oil. Such an oil very well satisfies the tests of the British Pharmacy.

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

Starting Up of a Grinding Shop

The grinding of motor parts and other machine parts offers another opening for the young Indian to start in business on his own account.

THE degree of accuracy which is possible to-day in the manufacture of motor-car engines and motor-car parts, is due almost wholly to the development of the modern grinding machine.

It will be readily understood that when a motor-car engine has worn sufficiently to require the reboring of the cylinders, that some form of grinder must be available if the work is to be carried out with any degree of accuracy. This could, of course, be done at the maker's works, but in most cases the procedure would be very inconvenient, particularly for motor owners over-seas.

The alternative would be for garage proprietors to instal the necessary grinding machines, and this will doubtless take place in the course of time; but the purpose of this article is rather to suggest that it would be a profitable undertaking to set up a small independent shop specially for the purpose of grinding, and in making this suggestion we are continuing our early suggestion of showing openings for the younger generation to start in business on their own account.

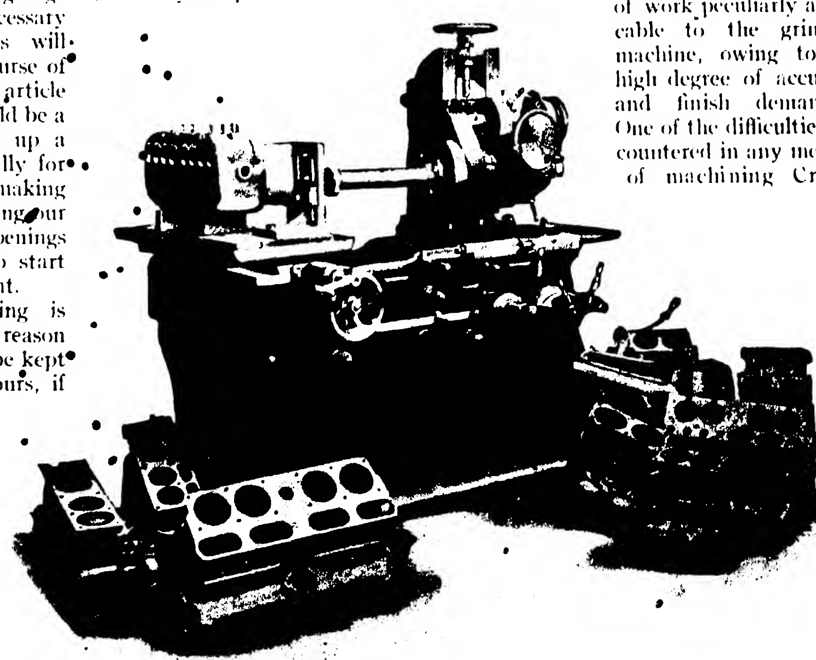
Machinery for fine grinding is relatively costly, and for this reason such machines will require to be kept working their full working hours, if they are to give a reasonable return on capital expenditure, and it is probably for this reason that the grinding machine has not been much more generally adopted in the garage itself.

We are inclined to believe that the independent grinding shop will be a feature of the future, and such a shop would not only secure the ordinary work which is now required for motor repairs, but it would actually make work. By this we mean, that in places where repairs are carried out and the people concerned are compelled to have the work finished in the lathe, if an independent grinding shop was available such work would undoubtedly be sent in for grinding, and such an independent grinding shop would collect work from a relatively large area of ground. Although the modern grinding machine is somewhat complicated and a very high class piece of mechanism, nevertheless, the working of these machines is like everything else, it is a very simple matter once it is thoroughly understood, and there need be little difficulty under this heading.

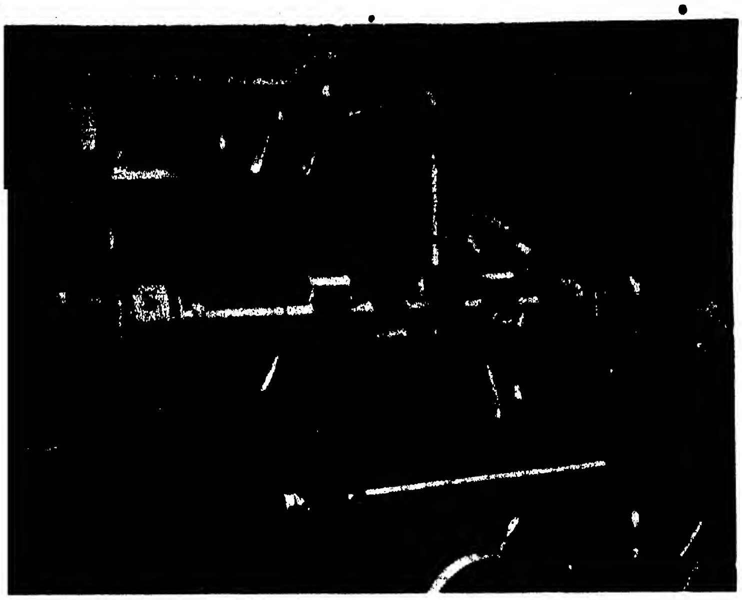
We are indebted to the Churchill Machine Tool Co. Ltd., Manchester, England, for the following details of the grinding machines illustrated and described in the present article, this firm having specialised in this particular class of work.

For the proposed independent grinding shop, there will, of course, be two principal machines necessary, namely: an internal cylinder grinder and external plain and crankshaft grinder.

The finishing of crankshaft pins and bearings, both for single and multiple throw crankshafts, is a class of work peculiarly applicable to the grinding machine, owing to the high degree of accuracy and finish demanded. One of the difficulties encountered in any method of machining Crank-



Internal Grinder at Work on Motor Car Cylinders



tails of how the work is supported

shafts is the securing of alignment of the crank pins in relation to each other, owing to the gradual release of various stresses in the shaft forgings, whilst the machining is proceeding step by step. It is for this reason that the grinding machine has been so successful on this class of work, the removal of the surplus material by grinding being a more gradual operation, and one that does not impart further stresses to the shaft. Crankshafts can also be economically ground direct from forgings or stampings; but if the full benefits of this method are to be obtained, the forgings must be specially designed to give the necessary clearance for the sides of the wheel.

The method adopted in the grinding of crankshafts is the use of a grinding wheel equal to the full width of a crank pin or bearing, using the wheel in much the same manner as a broad forming tool in the lathe, no traverse of the crankshaft being necessary. The fillets on the shaft are formed direct by the wheel, a special device being fitted to the machine for forming the corners of the wheel to the correct radii. The necessary support to the shaft whilst grinding is proceeding is given by a specially designed steady, which supports the shaft against the thrust of the wheel.

Crankshaft grinding machines are plain grinding machines, with the addition of crankshaft equipment, and specially arranged to carry the large diameter grinding wheels necessary for grinding crank pins.

Plain and Crankshaft Re-grinding in the Repair Shop

The Churchill Machine Tool Co. offer a specially designed 18" swing grinding machine, complete with crankshaft grinding equipment, and capable of handling all the plain grinding work, which is likely to be met with in the handling of motor repair work. This machine will accommodate work up to 60" in length between centres.

On this machine four work speeds and eight table traverse speeds are available, all instantaneously change-able while the machine is running.

The grinding wheel is 24" in diameter, and is sufficiently large to grind the pins of the largest Throw Lurry Crankshafts without fouling in any way.

The fillets on the shafts are formed direct by the grinding wheel, a radius truing device being fitted to the machine for forming the corners of the wheel to the correct radii.

The throw blocks are adjustable for stroke, and are fitted with three jaw chucks, see illustration, which will accomodate all the varying diameters of shafts and flanges, which are likely to be met with. The bearings are accurately divided for four or six throw crankshafts, special provision being made for securing the crank pins in correct alignment. As the throw blocks are mounted on ball journal bearings, tortional stresses in the crankshaft whilst it is being ground are reduced to a minimum. See illustration of the type of machine offered.

As a plain grinding machine it will accommodate work such as the grinding of automobile pistons, valve faces, and stems, axles, gear box shafts, knuckle joints, and transmission shafts, together with all the other cylindrical details of the modern engine, and transmission which are normally ground at the time when the engine is first assembled in the manufacturers works.

In addition to the above it is possible to fit to this machine an internal grinding attachment for the

18" x 58" "B" Model Crankshaft Grinding Machine

regrinding of motor cycle cylinders, and bushes, etc., this additional equipment involving very few extra parts and no structural alteration to the standard 18" × 60" capacity machine.

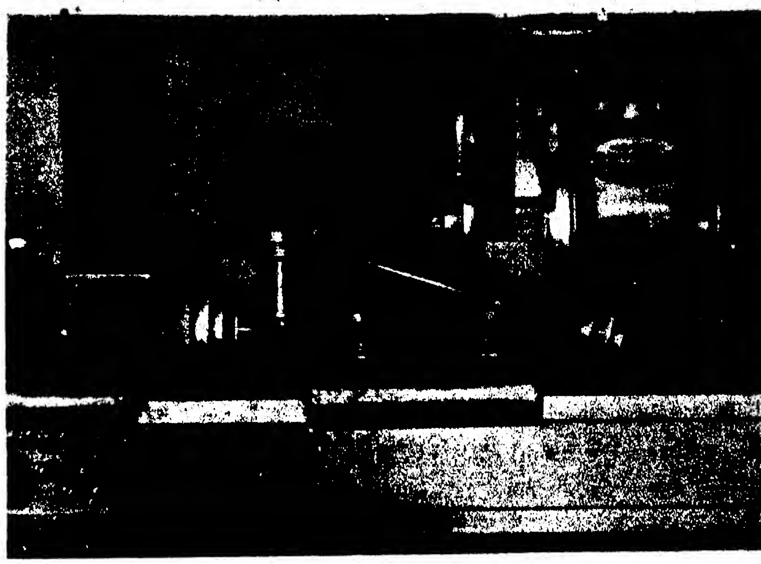
Cylinder Re-grinding

The Churchill No. 1 cylinder grinding machine has ample capacity for handling all standard motor-car four and six-cylinder blocks, also motor lorry four-cylinder blocks.

The outstanding features of the machine are its extremely rugged construction, 6" of vertical adjustment to the spindle, and the general principle underlying the design of the machine, which principle ensures the minimum of overhang when grinding the largest sizes of work, and the provision of cutting conditions which are absolutely constant throughout the whole machining operation.

With the travelling wheel-head type of cylinder grinding machine, such as the one offered, there is not the disadvantage of reciprocating an unweildy overhanging cylinder block, and this condition results in consistently accurate and rapid production.

Another feature of the machine is the facility with which the detachable



Valve Grinding Attachment

grinding snouts can be removed, as will be seen from the illustration. It is only necessary to take out the four bolts running through the snout flange. The illustration shows the grinding snout in position, with the two sizes of pulley supplied for fitting to the fixed end of the grinding spindle, these pulleys being supplied so that the correct speed of the grinding wheel may be maintained throughout the varying diameters which have to be used.

Included with the machine equipment are also provided a couple of angle plate fixtures, which will accommodate practically all the car and lorry engine cylinder grinding work which the machine is likely to be called upon to perform.

Messrs. CHAS. WALMSLEY & Co. Ltd., BURY, LANCS.

THE FAMOUS PAPER MAKERS' ENGINEERS

—have now linked up with—

Sir W. G. ARMSTRONG, WHITWORTH & Co. Ltd.

For some time past rumour has been busy connecting the name of the famous makers of Paper-making Machinery, Messrs. Chas. Walmsley & Co. Ltd., Bury, Lancs., with that of the Armstrong, Whitworth Group, and we are very glad to be able to state that rumour has not proved wrong.

As our readers will doubtless know, Sir W. G. Armstrong, Whitworth & Co. Ltd., established some time since a large Hydro-Electric Department, which is now busy in all parts of the world, and exceptionally so in wood pulp producing regions of the Northern Countries, and it is only natural that a combination between the two firms should prove advantageous to both. On the other side Walmsleys have reached such a high standard of excellence in the manufacture of paper making machines, that they occupy a premier position, not only in Great Britain, but in Canada, and wherever paper making machinery is installed.

The new Walmsley Company Ltd. will retain the services of Mr. John Wolstenholme as Managing Director, and Mr. William Adamson as Technical Director, but in view of the absence of Mr. Wolstenholme abroad, Mr. Adamson will act as Deputy Managing Director, and will work in the closest connection with Sir W. G. Armstrong, Whitworth & Co's. Hydro Electric Department, at 8, Great George Street, Westminster, S.W., whose offices will be used as the London Offices of Walmsley & Co. Ltd.

This working arrangement arrived at between the two firms, will enable the Walmsley Company to take advantage of the world-wide organisation of Sir W. G. Armstrong, Whitworth & Co. Ltd.

Low Temperature Carbonisation (iv)

By DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min.E., Mem. Am. Soc. M.E., A.I.Mech.E., etc.

In this the fourth of our series of articles on Low Temperature Carbonisation, Mr. Brownlie deals with the pioneer work of Messrs. British Oil & Fuel Conservation Ltd.

THE "Freeman" process of low temperature carbonisation is controlled by Messrs. British Oil and Fuel Conservation Ltd., 5 Hythe Road, Willesden, London, of which Mr. N. H. Freeman is the Technical Director.

The design of the "Freeman" Multiple Retort is based essentially on the fact that there is a number of definite and critical temperatures in the carbonisation of coal, and the retort is divided accordingly into a number of stages or zones, each of which is kept at a definite temperature by means of special accurate automatic control mechanism. The coal passes in succession through the different stages, and remains long enough in each for the particular and definite reactions to take place, and all the volatile products to be separated before passing in order to the next zone.

Thus, the first stage is the removal of occluded gases and water, which, according to Mr. Freeman, commences at 212 deg. F. (100 deg. C.), and may go on until as high as 500 deg. F. (260 deg. C.) The next stage begins with most coals at about 450 deg. F. (232 deg. C.), continuing as high as about 650 deg. F. (343 deg. C.), and consists in the metamorphosis of the greater part of the coal substance into a partially soluble form. During this stage no oil, and very little gas comes off, which in fact cannot happen until the transformation is complete. There is no apparent change in the constitution of the coal, but Mr. Freeman states that the process can be followed by taking samples and determining the amounts of oil by extraction in a "Soxhlet" apparatus.

The third stage is about 250 deg. F. higher than the second stage, and the distillation of the low temperature oil commences and finishes during this period, whilst also most of the gas is given off. The temperature is not as a rule, however, allowed to exceed a maximum of about 800 deg. F. (426.6 deg. C.), and Mr. Freeman proposes to call this the critical temperature which differentiates low from high temperature carbonisation. He is of the opinion that immediately above this temperature the carbonisation assumes a different character, tar, pitches, naphthalenes, anthracenes, phenols, and similar substances being formed, together with an abundant evolution of free hydrogen, which are characteristic of high temperature carbonisation.

As already stated, the "Freeman" Multiple Retort is designed so as to submit the coal in succession to these various critical temperatures, and is constructed with six stages, the last of which is a cooling zone to enable the residual low temperature fuel to be discharged into the air without difficulty.

The retort and general plant at Willesden is illustrated in detail in the section drawing Fig. 1, and in the frontispiece of this issue. The complete installation includes coal pulverising and conveying plant, Fig. 4, one retort with a capacity of 10 tons of coal per day of 24 hours, an oil refining plant capable of handling 500 gallons of oil a day, a total gasification plant of 2½-5 tons solid fuel a day, a desulphurising plant, and a briquetting and powdered fuel plant. The "Freeman" retort is also particularly applicable to the distillation of shale, torbonite, and similar material, and in fact was originally designed for this purpose, and subsequently adapted for the carbonisation of coal and lignite at any required temperature, the installation at Willesden being designed to handle any of these fuels. A view is also shown of the laboratories where sample 10 lbs. of fuel can be tested.

The retort is of the vertical continuous type, having a height of about 37 feet and a diameter of 5 feet. The coal, or other fuel, roughly pulverised so as to pass through a 10's mesh sieve is conveyed automatically into the hopper (A), Fig. 1, and is fed continuously through the feeding valve (B), actuated by means of an eccentric driven from the main drive, into the first chamber or zone, each of these chambers being marked (C). These chambers are heated by producer gas which enters through the pipes shown, and by means of the "Freeman" automatic regulating mechanism—which will be described shortly—each chamber is maintained at a constant temperature.

The pulverised fuel is stirred continually by means of slow moving ploughs or scrapers (L) attached to the horizontal revolving plate (K), driven by a central vertical shaft. The fuel is in each of the chambers approximately 17 minutes, and is maintained at 350 deg. F. for this time in the first chamber, whilst being kept in slow motion so as to expose every particle of the coal to the action of the heat. The occluded gases and practically all the moisture is driven off in this stage, the volatile products escaping through the pipe (D). When the coal has completed its travel round the chamber in 17 minutes, it falls through the chute (M) into the second chamber below. Here the temperature is maintained at 450-500 deg. F., being, as before, stirred slowly and kept in this stage for 17 minutes. Here the remainder of the moisture is driven off through pipe (D2), and the transformation of the coal substance takes place. In the third stage the temperature is 600 deg. F., and a considerable amount of light oil is given off, together with gas, the volatile products as before passing through the exit pipe (D). Each of these exit pipes (D) is connected to a coal condensor (H), cooled with water. The condensed liquid products collect in the receivers (G), and the gas passes on to the gas main (F) connected to a gasometer.

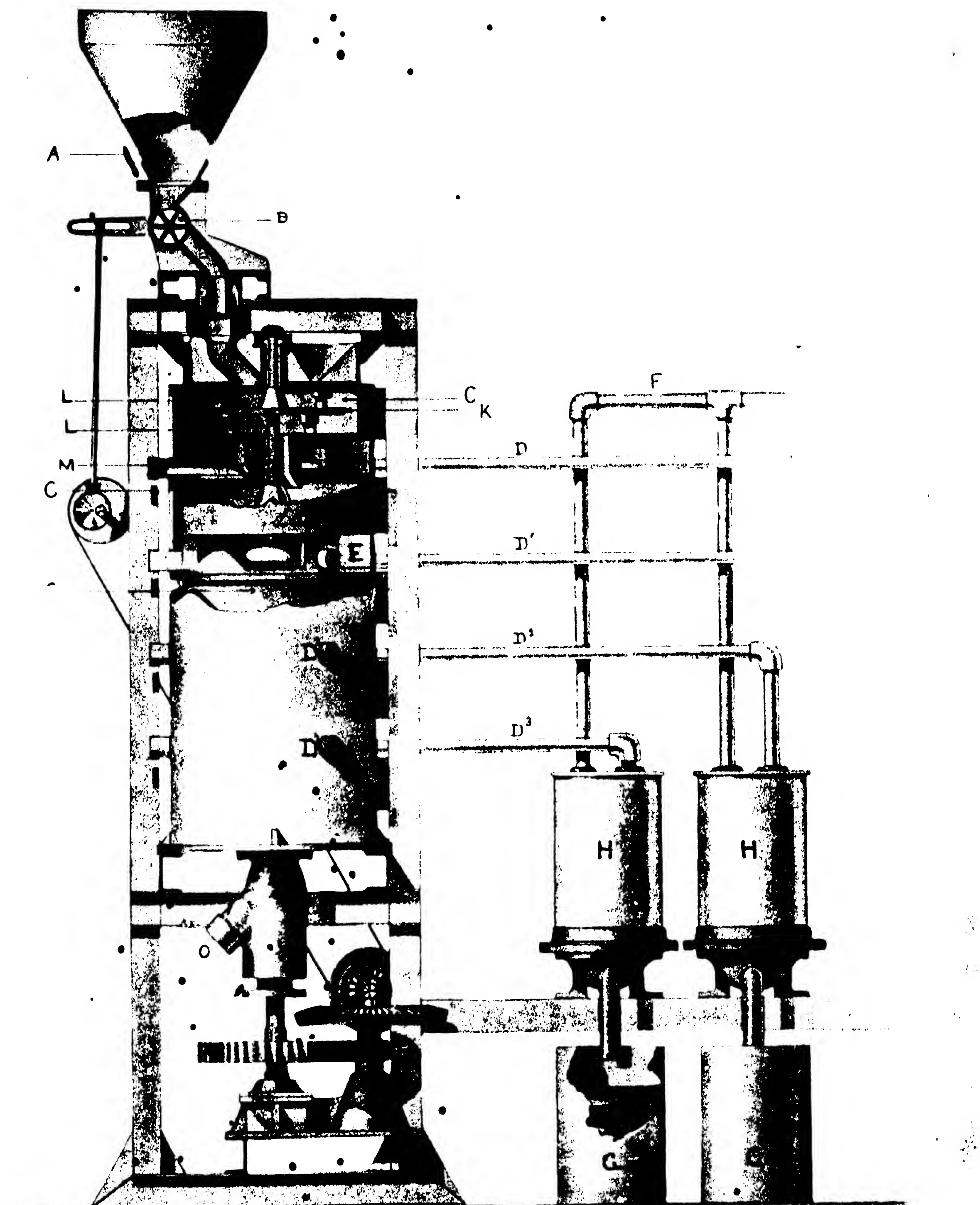


Fig. 1. Diagram of Freeman Multiple Retort

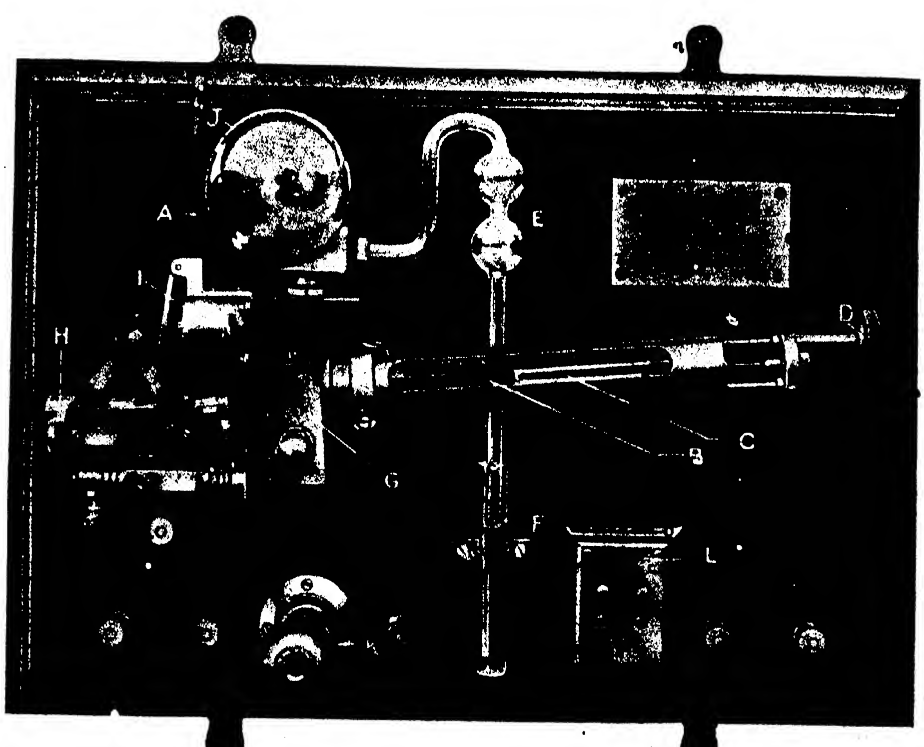
The illustration in Fig. 1 is only for a four stage retort, but the modern installation at Willesden is, as shown in the frontispiece, a 6-stage retort, which is now the standard type. The principle and method of construction is, however, exactly the same, with producer gas inlet pipe, automatic temperature control to each stage, gas outlet pipe, condenser, and gas main.

In the fourth stage the temperature is 650 deg. F., and a considerable portion of oil and gas is evolved, whilst in the fifth stage the temperature is 750-800 deg. F., the last of the oils being driven off. The last stage is simply a cooling chamber, with a current of cold air passing round the outside. The low temperature fuel, being of course in the pulverised condition, is then discharged through the discharge pipe (O) into a truck, or any convenient receptacle. The temperature of the residual fuel passing through (O) varies from 100 deg.-400 deg. F, depending on the quality of coal and the speed of working, and the design of the cooling chamber prevents all danger of the fuel igniting when it first comes into contact with the air. The method of driving the retort will be clear from Fig. 1, consisting of vertical driving shaft, to which each of the revolving plates are attached, with horizontal gear wheels driven by motor. The power required is very small, being for this size of retort only about 5 H.P.

An essential part of the "Freeman" retort is the "Freeman" precision temperature regulator, illustrated in Fig. 6.

(A) is an air lead or tube to the source of heat, a separate regulator being connected independently to each chamber, the battery of six regulators being situated in the house on the left of frontispiece. This air lead terminates in an air bulb, which is placed directly in the heated chamber. The slightest change in the temperature causes a corresponding expansion or contraction of the air inside the bulb. This bulb is in connection with a short column of mercury contained in a glass tube (B) at a slight angle to the horizontal, and the change in volume in the bulb causes the mercury column to move accordingly, the mercury making a contact with the point (C), the position of which can be adjusted by the fine screw thread (D). Also in direct communication with the air lead (A) from the air bulb is a column of oil contained in the vessel (F), in which a glass tube (E) dips below the surface, forming an oil seal, which also serves as a convenient indication to the attendant as to the change of temperature in the chambers. The horizontal mercury column (B) is mounted on a trunnion (G), so that it can be rotated as required and brought, if necessary, almost completely horizontal, the smaller the angle to the horizontal the more sensitive being the instrument. A valve is fitted in the producer gas supply pipe to the chamber, operated either by a compressed air piston, or a solenoid magnet, operated by a nitrogen tube switch (H), actuated by an electro magnet (I). This magnet is excited when the mercury column (B) makes contact with the point (C). (J) is a pilot lamp, (K) a socket for a resistance lamp, and (L) a double pole switch.

It is claimed that this mechanism is so sensitive that the temperature can be controlled to 1 deg. F., and the results obtained with the "Freeman" retort are only possible because of this sensitive and automatic control of the temperature. The apparatus can, of course, be used for the control of temperature in any process, and in addition to that of the carbonisation of coal, shale, and other solid fuels, has a wide application in such varied



Freeman Precision Temperature Control

View of one of the Laboratories at Willesden

industries as the heat treatment of steels and alloys, the annealing of glass, in the pottery and ceramic industries, oil refining, biscuit manufacture, in the dye, explosive, and chemical industries, etc. The bulb is made of any desired material, metal, glass, silica, porcelain, carbon, etc., according to circumstances, in the case of the low temperature carbonisation of coal, being usually of steel.

For a large scale installation, the most satisfactory unit is a retort of 100 tons of coal per 24 hours, the height being 45 feet, the diameter 16 feet and the total horse power required 40, whilst the capital cost is very low in comparison with most low temperature carbonising plants.

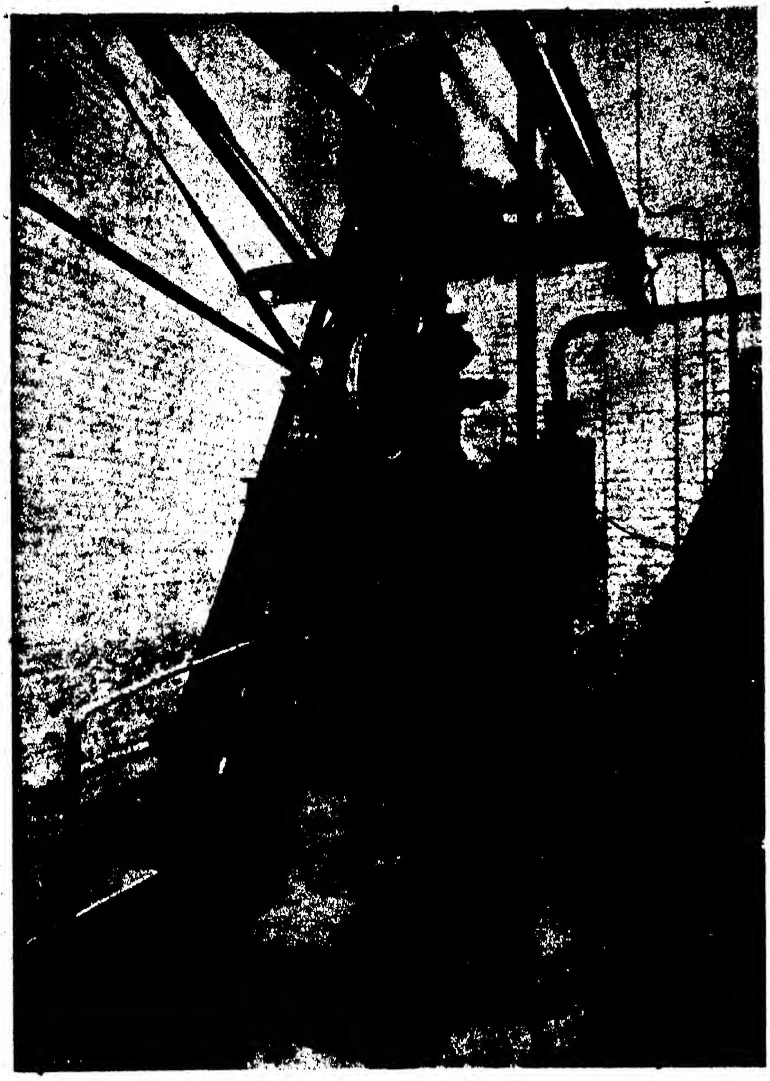
As will be seen the working of the retort is continuous and automatic, the labour and attendance required being reduced to a minimum, whilst the total time of carbonisation is under two hours. The speed of the working of the retort can, of course, be controlled at will, according to the quality of the fuel, and the nature of the products required. For average coal, as already stated, the duration of each stage is 17 minutes, being a total of 102 minutes. It is claimed that this retort obviates most of the difficulties of the low temperature carbonisation of coal, such as the length of time required, inequality of carbonisation, irregularity in quality of the fuel produced, together with high capital outlay and huge ground area required for the plant. The yield obtained by this process from one ton of average coal, coking and non-coking together, in approximately the same proportions as they occur in the British coal-fields, is as follows :—

1200 cubic feet gas (750 B.Th.U. per cubic foot).
25 gallons oil.
15-15½ cwt. of residual smokeless fuel.

No ammonia is formed in this process, as the final temperature is not high enough to decompose the nitrogenous organic matter of the coal to form ammonia, this reaction only commencing at about 850 deg.F.

The gas evolved, although small in amount, is of very good quality, being rich in methane and in ethylene compounds. The oil yield is not only very high, but the product is also extremely valuable because of the almost entire absence of "cracking" during the process. The yield of motor spirit obtained on fractionation is extremely good, being about five gallons. There are no phenols, cressols, naphthalenes, or anthracenes, characteristic of cracking and high temperatures, and about eight gallons of lubricating bases can be extracted. The crude oil can, of course, be used direct as fuel oil, whilst after the separation of the five gallons of benzole from the 25 gallons of crude oil, at least 10 gallons of the residual oil is suitable for "Diesel" engines. The oil residues also contain no pitch or free carbon.

The residual smokeless fuel in the rough powdered condition has about 7-9 per cent. volatile matter still present, and something like 80-85 per cent. fixed carbon, and it is claimed that the percentage of fixed carbon is higher than that of any other low temperature process. This residual fuel can be utilised in various ways. In the first place it may, without much extra trouble, be further pulverised and used instead of coal for powdered fuel firing. Also the temperatures in the different stages may be altered so that, if the oil yield for a given coal is not high, more of the volatile matter may be left in. This type of residual fuel is then particularly suitable for briquette making, prac-



Pulverising and Conveying Plant

tically no binder being required. One of the great advantages claimed for the "Freeman" retort is that it is flexible, and the treatment can be varied without trouble according to the quality of the coal. In the case of many low volatile coals it may not pay to separate the maximum amount of oil, and each case has to be considered on its merits. Generally speaking, it does not pay to retort specially for oil if the volatile matter is less than 20 per cent., and if only a few gallons of oil are to be obtained, then it is much better left in for briquetting, to increase the efficiency of the powdered fuel firing, or to give a richer gas in the case of total gasification.

Another very convenient method of utilising the fuel is total gasification, either for lighting, or for the production of power in gas engines. The "Freeman" plant for the complete gasification of the residual fuel is continuous in operation, and the producer gas formed is of high quality. It is claimed that whilst in ordinary towns gas practice, using a good quality coal with low ash and high volatile content, the average yield of gas is 20,000 cubic feet of gas per ton with 10 gallons of coal tar, the same coal in the "Freeman" multiple retort will give 25-35 gallons of high grade oil, and 65,000-70,000 cubic feet of gas.

The figures mentioned are averages, but it will not be without interest to give the actual results obtained with a particular coal, an unwashed Derbyshire slack of inferior quality, with the following analysis:—Moisture 5.3 per cent., ash 14.85 per cent., volatile matter 24.95 per cent., and fixed carbon 54.90 per cent.

The yield from 1 ton of this coal as received was 1133.4 cubic feet of gas of high quality (670 B.Th.U. per cubic foot), 251.9 lbs. of oil (corresponding to 25½ gallons of oil per ton) 221.7 lbs. of water and 1692.3 lbs. of residual fuel. The analysis of this fuel was 10.39 per cent. volatile matter, 73.26 per cent, fixed carbon, and 16.35 per cent. ash. In this particular experiment the temperature in the fifth chamber was higher than usual, the maximum being 883 deg.F. (482 deg.C.), but the evolution of all oil and volatile products had ceased at 820 deg.F. (438 deg.C.)

Mr. Freeman contends that a greater part of the millions of tons of small and refuse coal dumped round the pit heads, or left down the pits, could be economically employed in his multiple retort for the production of gas, motor spirit, naphtha lubricating oils and greases, or for fuel oils, which would be worth £2-3 per ton based on the coal, whilst the residual fuel would be equal in value to the original coal. It may be pointed out also that the residual coal can be used alone, or mixed with coal, in any existing high temperature carbonisation plant.

Although this series of articles is not concerned with the distillation of shale, it will be interesting to devote a short space to this question, since the "Freeman" multiple retort is specially applicable to shale distillation. There is no question that two of the most important industrial problems are the low temperature carbonisation of coal and the distillation of shale. The known shale deposits of the world, calculated as actual heat in the form of shale oil content, are infinitely greater than the coal and lignite reserves put together, and no systematic attempt has been made as yet to find shale. The world's petroleum reserves, which are failing, are infinitesimal as compared with the oil in shale.

Vast shale deposits occur in Great Britain, especially in Norfolk, Yorkshire, and Dorsetshire, but the only development of any importance is in Scotland. The process of shale distillation consists in heating the shale in various types of retort, anything from say 25-150 gallons to the ton of oil being obtained, according to the quality of the shale, together with varying amounts of gas. One of the great problems has always been to

find a use for the residual spent shale. Mr. Freeman contends that the present general methods of shale distillation are on wrong lines, and to get the best results it is necessary to heat it in succession at various critical temperatures, on analagous lines to the low temperature carbonisation of coal. Also shale must be distilled at low temperatures, and much of the valuable products are destroyed in the present general methods, because of excessive temperature. All shales contain more or less water, and this is driven off in the first stage of the retort as already described for coal. Mr. Freeman is of the opinion that the critical temperature of most shales is 650-750 deg. F., this being the narrow limits within which the oil comes off, shale being in this respect similar to coal, and if the temperature exceeds 752 deg. F. (400 deg. C.), much of the valuable oil is destroyed, whilst at the same time pitches and tars are produced, which make the oils very difficult to refine because of their emulsifying action. The "Freeman" retort was designed on the theory that in order to get the maximum economy in shale carbonisation, it is necessary that the shale should be in a roughly pulverised condition, the temperature must be in different stages under control, the contents of the retort must be constantly agitated to prevent the vapours being entrapped, and to allow them to get away as soon as possible to prevent cracking. British shales treated in this way give 40-80 gallons of oil per ton, together with 1,500-2,000 cubic feet of gas, and it can be taken as a practical figure that every 1 per cent. organic matter in the shale will give 1¼-1½ gallons of moisture-free oil per ton of shale. In this process also the residual spent shale can be utilised in a total gasification plant, the yield being 1,000 cubic feet of gas for each 1 per cent. of fixed carbon in the residual fuel per ton of residue. In averages, the fixed carbon content of this residue is 30 per cent., corresponding to 30,000 cubic feet of gas per ton, the gas having an average quality of 300 B.Th.U. per cubic foot.

The figures for a typical Norfolk shale of 27.45 per cent. organic volatile matter are as follows:—The oil began to distil at 460 deg. F., and at 710 deg. F. the yield was 41 gallons to the ton. Any further increase in temperature resulted merely in wax, tar, and heavy pitch.

Another typical sample of a Norfolk shale was 6.2 per cent. as free water, the fixed carbon being 18 per cent., the ash 41 per cent, and the total volatile matter, including free water, 41 per cent. In the "Freeman" multiple retort this shale gave 13.55 per cent. total water (7.30 per cent. free and 6.25 per cent. combined), 17.95 per cent. oil, 7.42 per cent. as gas (3,500 cubic feet), and 60.71 per cent. as spent shale residue, with 0.37 per cent. loss. The specific gravity of the oil was 0.973, and the yield corresponds to 41.32 gallons per ton of raw shale. The gas is luminous, the last portions being highly luminous. The spent shale residue is 6.00 per cent. volatile matter, 40.97 per cent. fixed carbon, and 53.03 per cent. The maximum temperature at which the output of oil ceased was 680 deg. F.

The World's Oil Production

In connection with the great publicity that has been given to the possibilities of oil firing, the figures for the world's oil production of 1921, recently published by the American Petroleum Institute, will be of great interest. It is difficult to get exact figures in some instances, particularly Russia, but the total production for the year is just over 700,000,000 barrels. The United States production was 470,000,000 barrels, and as the home requirements were 525,000,000 barrels, considerable alarm is being felt at the threatened approaching exhaustion of the American oil wells. Hence the great interest evinced by the United States in the Mexican oilfields, the production of which has increased enormously, being now about 190,000,000 barrels per annum.

In connection with the suggestion to adopt oil firing, it is interesting to remember that in the first place over 80 per cent. of the oil production of the world is controlled by American financiers, whilst Great Britain controls less than 5 per cent. Of the 2¼ per cent. produced within the British Empire, India produces 1½ per cent. Secondly, the present world's output of 700,000,000 barrels is only sufficient to replace 175,000,000 tons of coal, or about 12 per cent. of the world's output, and not sufficient to replace the coal used in Great Britain alone. Finally, also, there is no certainty of supply with the oil, and the present known reserves are failing, whilst there is enough coal in the world to last over 4,000 years. It is not to be wondered at, therefore, that oil is far too expensive in comparison with coal, and when the price in Great Britain is about £2 10s. a ton, as compared with coal at say 35s., we can then consider the matter seriously.

In connection with oil, increasing attention is now being given throughout the world to the distillation of shale, and the production of shale oil. Average shale on distillation gives about 100 gallons of oil to the ton, and considerable improvements in the process have recently been effected by the Colorado School of Mines (U.S.A.), Research Department. A big development is also pending in Australia, where a plant is now in operation at Joadja (New South Wales), which it is expected will produce 15,000 gallons of oil a day before the end of the year. Further, two British syndicates have been granted concessions to exploit the shale deposits in Esthonia, the proposal being to lay a pipe line direct to the Baltic ports. Shale exists in the world in almost inexhaustible amounts, far exceeding even coal and lignite, and there is every possibility that in the future shale oil, together with the oil produced by the low temperature carbonisation of coal, will prove a formidable rival to petroleum.

Recent Machine - Tool Developments

Some recent machine tools designed for special work are described in this article.

WE have received some interesting particulars, together with illustrations, from several well-known British machine tool makers, and propose to devote this article to a brief summary taken from the information which these firms have supplied to us.

We will deal first with some of the machine tools manufactured by Messrs. Joshua Buckton & Co. Ltd., of Leeds, for use in railway shops. Space forbids us to discuss general purpose machines, such as slotters, drills, and light lathes, which would of necessity form part of a complete plant for the manufacture of railway equipment, but will confine ourselves to a few special tools.

These will be considered under the headings of tools for (1) Plates and frames, (2) Wheels and axles, (3) Spring work, (4) Rails-points and crossings.

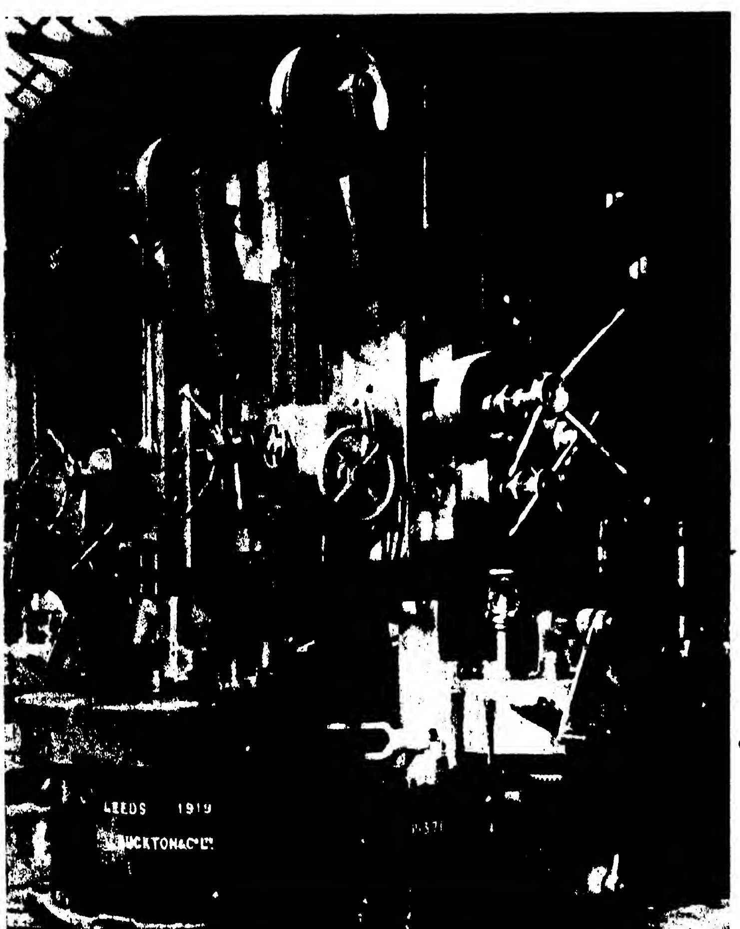


Fig. 2. Vertical Boring and Turning Mill — *Joshua Buckton & Co. Ltd.*

Plates and Frames

The Buckton Plate Edge Planers, Fig. 1., are to be found in the leading locomotive, marine, and industrial boiler shops in England, and on the Continent. They are driven by belt or motor as may be desired, and are all designed with automatic reversal of the saddle. They are arranged for cutting on both strokes, with or without automatic vertical feed, and are driven either by quick pitch screw or in the largest sizes, by spiral pinion engaging with a rack fixed to the bed. The holding down of the plates is effected by screws or hydraulic rams, and the machine admits plates of unlimited length.

The standard frame plate slotter is a massive machine carrying three travelling heads with uprights and cross member cast in one. The heads may be placed facing in the same or in opposing directions. Each head carries a saddle with its independent motor driving the slotting tool for rectangular, taper or circular slotting. The rams are counterbalanced, and all the driving mechanism is enclosed and lubricated by a constant cascade of oil.

They also manufacture four and six spindle tube plate drills, with balanced spindles independently controlled and arranged, if desired, for tapping. They are designed for drilling holes up to 2½ ins., (64 mm.) diam., at high speed. The lubricating arrangements are very complete. Another special type is an 8 or 10 spindle drilling machine for wagon knees and bars.

Wheel and Axle Shop

Admits many specialised tools for the economic and rapid production of its output, though there still exist works which sacrifice efficiency by the use of general purpose machines,

Fig. 1. Plate Edge Planer — *Joshua Buckton & Co. Ltd.*

which are not specially adapted for the work.

Though Bucktons' make general purpose machines, their special plant is becoming more and more the recognised standard. First in order of process, among the special machines to be now considered, is the Vertical Boring and Turning mills (Fig. 2), for turning wheels and boring and turning tyres on all the machined faces. These machines are of exceptionally massive and powerful design, for taking the heaviest cuts on hard tyre steel. The cross slide is fixed and carries two tool slides, each with self-acting feed motions for horizontal, vertical or angular cuts and balanced by counter-weight. Each is fitted with independent control. The circular table is fitted with a 5-jaw concentric chuck, for internal or external gripping. The drive is through change speed gear box by belt or motor.

For boring and facing the boss of wheel centres, they manufacture a Special Mill (Fig. 4), provided with a vertical counter-balanced boring bar of 10½ in. (267 mm.), and where desired, with a horizontal hub facing slide. A pneumatic crane may be fitted for handling the work.

It is especially noteworthy that the gearing and the wide bearing surfaces of the table of both these heavy duty machines run in a complete oil bath, in which the working surfaces are submerged.

Another method of boring tyres of medium diameters is by means of the Buckton Duplex tyre boring lathe. This machine consists of two self-contained units, served by an over-head run way, and so designed that the work in both headstocks may be controlled at the same time by one man. Each unit is fitted with two saddles, whose slides have hand and self-acting feeds. The drive is by independent electric motors.

Wagon and carriage axles are turned in a double ended lathe, designed for turning the axle journals and wheel seats at one setting, the axle being driven by a central head-stock so arranged as to prevent distortion of the axles. The two saddles have self-acting feed in either direction, and automatic knock-off gear. The handles for reversing and changing the feeds are brought under the central headstock, within easy reach of the operator.

Both this machine and a special crank axle lathe are the outcome of a long experience of efficient lathe design, and an intimate knowledge of the requirements of modern railway shops. At this point we may consider the hydraulic wheel press for pressing the wheel centres on to their axles. These have been made, develoved and

Fig. 3. Testing Machine for use in Railway Spring Manufacture — *Joshua Buckton & Co. Ltd.*

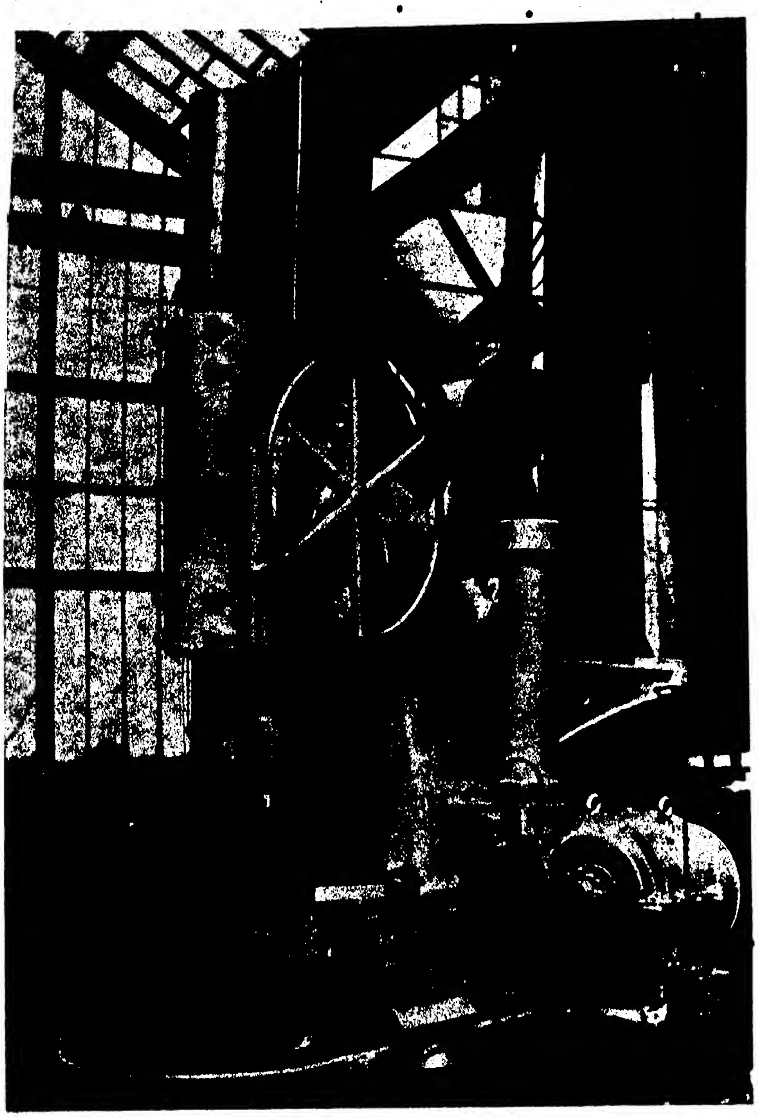


Fig. 4. Special Mill *Joshua Buckton & Co. Ltd.*

Spring Work

A large number of the tools found in the spring shop are of special design. These are, of course, to be found among Messrs. Bucktons' manufactures.

As examples, may be mentioned the spring punching, shearing, nibbing and slotting machines. But they have developed in addition, various forms of testing machines, one of which is illustrated (Fig. 3), for the use of railway works spring manufacturers, arranged for drive by belt, motor or hydraulic power. These machines are in regular use by many great railway systems, amongst which may be mentioned the Belgian State Railways. Scragging may either be done on a special machine, or on a spring testing machine provided with wedging mechanism so as to relieve the weighbridge of the shocks of repeated compression. The same machine may be used for laminated and helical springs, and in the standard patterns exercise a maximum load of 35 tons (35,000 kilos.)

Rails, Points, and Crossings

The need for special rails, points and crossings has called for special consideration of the plant for producing them. Messrs. Bucktons make several important machines for the necessary processes. First in the list, we will take the bender and straightener. The duty of this tool requires no explanation, but it is essential that it should be able to perform this duty with a great degree of exactness. This is allowed for on the Buckton type in designing the control of the moving ram. In passing we would note that the same machine may be used for bending or straightening girders. Next, the ends of the rails must be dressed. In the Buckton bending machine, the rail is held stationary in a vice while the cutting head, with its revolving blades, is traversed by power towards the rail; on the completion of the cuts the head can be rapidly returned to its original position.

The drilling and ovalling machine, which follows in the natural sequence of manufacture, has horizontal spindles for drilling four simultaneous holes in the heaviest rails and at high speed. The spindles are in pairs on each side, adjustable from 7 ins. (178 mm.) to 14 ins. (355 mm.), apart with disengaging stops adjustable for any depth of hole.

The ovalling is done by hand motion.

The rail planing machine for points

supplied by Bucktons' from the earliest days when they were called into use. They are for 150, 250 or 350 tons capacity to take wheels of any specified size. The main cylinder and pressure heads are of cast steel. An adjustable lifting sling is carried overhead. The machine carries a set of motor driven pumps to give the necessary hydraulic supply.

An automatic recording pressure gauge may be fitted when desired.

Finally, in this department is the wheel lathe, designed for finishing the tread and flange after the wheels are mounted on their axle, or for returning them when worn. Of these they have a wide range of designs, varying both in size and in weight, for heavy or light duty. The usual limits are from 3 ft. 6 ins. (1065 mm.) to 7 ft. 6 ins. (2285 mm.), diameter of wheel tread, and from 5 ft. 4 in. (1625 mm.), to 9 ft. 9 in. (2970 mm.), between the centres, according to the gauge of railway to be served. A distinctive feature of the larger machines is the internal ring of cut gear on the faceplates, providing the final drive. Back saddles may be provided in addition to front ones if required. The methods of wheel gripping, tool holding, calipering and the withdrawing of the centres have all been most carefully studied down to the last detail, with a view to increasing the output of these machines with the least possible loss of time in handling.

and crossings has been developed from the general purpose planer. It is capable of the heaviest duty, cutting hard rail steel at a high speed. To provide for point planing, there is carried on the main reciprocating table a second table of full length, which may be tilted out of the horizontal by means of powerful screws and locked at the required angle. This machine (Fig. 5) is the most powerful and reliable rail planer yet designed, and is used by numerous railway administrations as well as by contracting firms.

A method of testing 3-jaw chucks is illustrated, showing a new setting guage, which Messrs. Alfred Herbert have just devised to simplify the setting of the three jaws to the same diameter. Hitherto, this firm have always relied on the serrations, and the concentric rings turned in the face of the chuck. This, however, has not always proved satisfactory, and so they have designed the guage illustrated.

By the use of this gauge, it is a very simple matter to set the three jaws concentric, so that they will grip any desired diameter without trial. The use of the gauge is clearly shown in the illustration, and needs practically no description. It consists, however, of a block which rests on the periphery of the chuck with a graduated rod, which can be set to the diameter to which the jaws are to be fixed. Messrs. Herbert have already thoroughly tested this gauge out in their own shop, and it has been found a very great time saver.

The following two special drilling machines are by Messrs. Haighs (Oldham) Ltd., and we have extracted the following from the firm's specification.

Four Head Radial Drill

The machine is arranged for dealing with girder plate, structural and tank drilling, and consists of four heads, each driven from a common shaft by electric motor, each independently adjustable by hand along the common bed.

The spindles are of high carbon steel, and are driven through spur and bevel gears from a variable speed motor. Three rates of feed to each spindle, which can easily be stopped, started and reversed. Hand feed motion is also fitted. Thrust is taken on a ball race.

The radial arms are of strong construction and are easily swung round as they are mounted on ball and roller bearings. Efficient and convenient locking device carried on each saddle enables operators to lock each arm from the working position.

Simple Chuck Gauge — *Alfred Herbert & Co. Ltd.*

The pillars have wide spread bases well gibbed to bed along which they are adjustable by hand through cross handle rack and pinion.

Multiple Drill

This machine is designed for drilling small rivet holes, etc. It is used in conjunction with suitable jigs, and consists of troughed baseplate on which are mounted three standards, cross frame carrying the 10 gear heads each driving eight spindles, table, pumps and fittings.

The Gear Heads each drive eight spindles, and are adjustable by hand along the cross frame, to which they can be bolted in the desired position. The ten heads are driven through

CAPACITY OF 3 AND 4 HEAD MACHINES.	3 HEAD.	4 HEAD.
Diameter of spindle	2¼"	2¼"
Bore " " nose	No. 4 Morse	No. 4
Traverse "	15"	15"
Spindle speeds single gear	400-133	400-133
" " double gear	120-40	120-40
Feeds cuts per inch.	40-58-85-135	40-58-85-135
Max. radius of spindle	5' 3"	5' 3"
Min. " " "	16"	16"
Max. distance spindle to table	21"	21"
Size of table	25' × 2' 6"	40' 0" × 2' 6
Height of table from ground	27"	27"
Centre of table to centre of bed	36"	36"
Length of bed	21' 9"	36' 9"
Max. centres of outer pillars	18' 9"	33' 9"
Width of bed	30"	30"
Depth of bed	18"	18"
H.P. of 3 to 1 variable speed motor	25/30	15/20
Floor space arms swing full circle	33' 0" × 14' 0"	48' 0" × 14' 0"
" " " " 2 half	33' 0" × 9' 0"	48' 0" × 9 0"
Approx. net weight	16 tons.	20 tons.
" Gross "	17 tons.	21 tons.
Shipping space	1050 cu. ft.	1100 cu. ft.

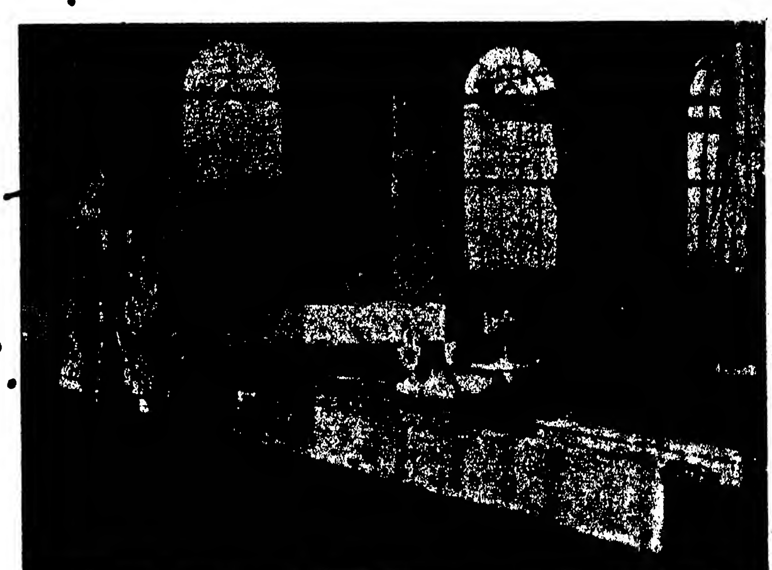
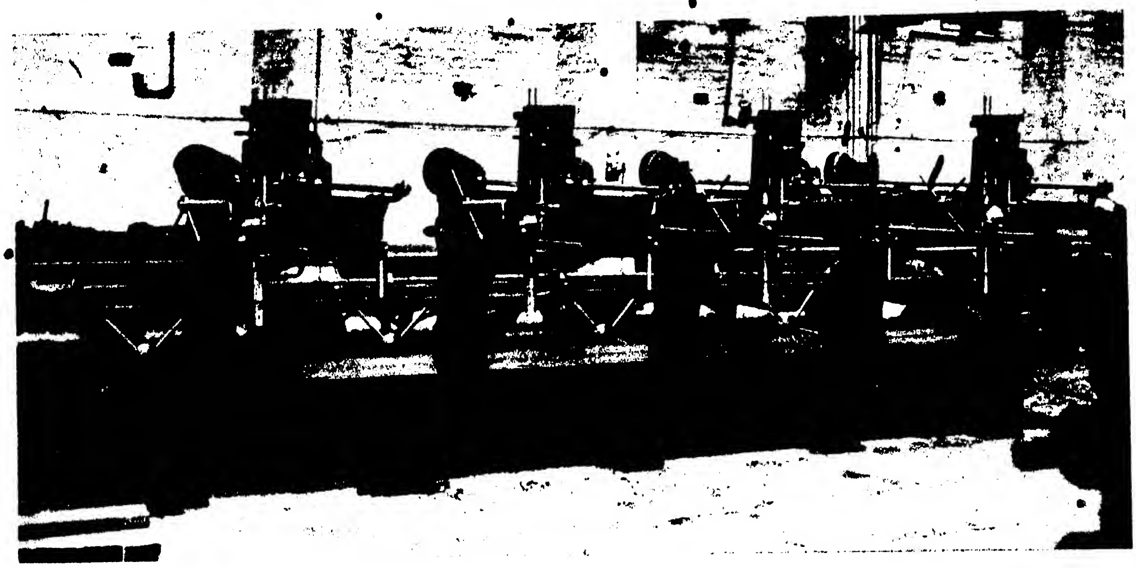


Fig. 5. Rail Planer — *Joshua Buckton & Co. Ltd.*



Four Head Radial Drill *Haighs (Oldham) Ltd.*

mitre gears from a common shaft mounted on ball bearings, and fitted with fast and loose pulleys at each end. The central gear shaft on each head runs in ball bearings, whilst each spindle pinion shaft revolves in phosphor bronze bushes. The central gear and the eight pinions are completely enclosed, and efficient lubrication is arranged to each bearing, ensuing remarkably quiet and easy running. Each spindle nose is bored No. 1 morse, and is carried in a long bearing bracket adjustable horizontally in any direction, and locked to the cross frame by two bolts. All the drill spindles are fitted with two universal joints, and telescopic shaft, which will work smoothly up to an angle of 36 deg. from the vertical.

Table Adjustment

The Table is vertically adjustable by handwheel; either direct through mitre gears to the two screws, or through powerful worm and wheel purchase, the former for raising or lowering quickly, and the latter for actual cutting, the change from one to the other being made by lever on the front of the table, which operates a clutch sleeve between the direct mitre gear and the worm reduction. The table and elevating gear is balanced by easily accessible weights hanging at the back of the machine. Ball thrust bearings are fitted to each vertical screw, also to the mitre and worm gearing.

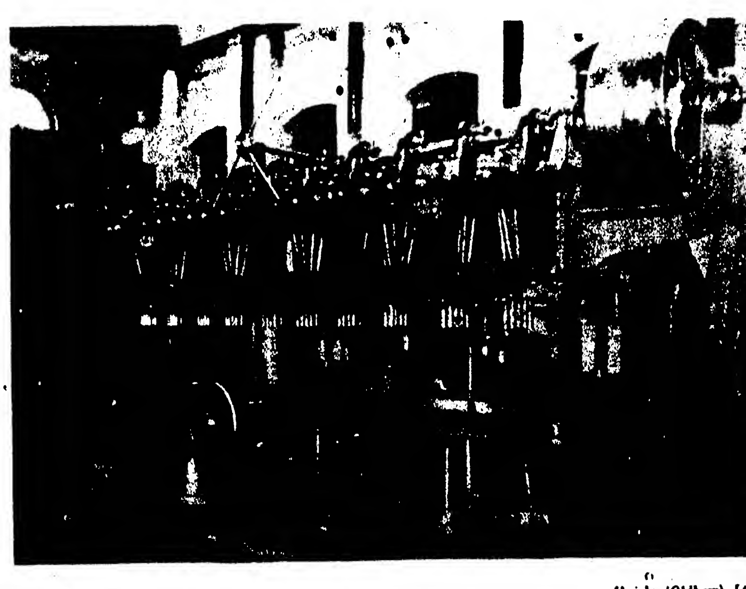
Water Spray Pipes

The Baseplate is troughed and arranged to form a sump for the water service, the two pumps being driven from intermediate shaft taking its drive from the main driving shaft, and serving a series of 40 spray pipes, the water returning to sump by way of table-trough, and pipes.

The Machine is supplied complete with necessary spanners and lubricators, and all gears are guarded where necessary.

Submarine Engines for Electric Power Stations

War, it is a comfort to reflect, has its uses for times of peace, especially when it involves the capture of valuable engineering plant. When Germany surrendered its submarines, six of the engines thus provided were installed in a British electric power station, the total cost being about half the ruling cost of ordinary engines of a similar capacity. The engines were thoroughly overhauled and reconditioned by a British engineering firm before being put into action again; and as they were oil driven they proved of great value during the coal strike last year. They have also proved much more economical than the steam driven sets, which previously did the work in that station.



Multiple Drilling Machine *Haighs (Oldham) Ltd.*

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE :: :: :: :: DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS :: :: :: ::

Recent Developments in Power Production

(*Continued from page 31.*)

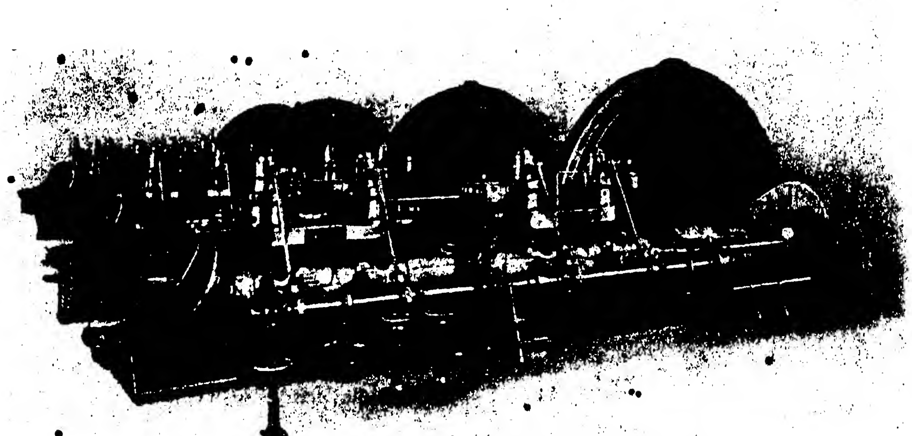
The following abstracts are from Mr. D. L. Selby-Bigge's paper read before the Iron and Steel Institute, London

DURING the past ten years remarkable improvements in steam turbine practice have been established by developing the use of higher steam pressures and higher superheat on the one hand, and by the adoption of higher turbine speeds on the other. The first of these two developments represents a direct improvement in efficiency of the thermal cycle of the steam, whereas the trend towards high-speed turbines offers advantages in various directions, distinct features being improved steam economy and reduction in the size of the machine for a given output, resulting in reduced first cost and in saving of floor space.

The general trend towards highest possible turbine speed must be viewed separately, as this particular development has only been possible owing to the improved methods of design and the production of high class steels for the running parts of the turbine, but to the great developments which have taken place in mechanical speed reduction gears.

Mixed Pressure Turbines

Mention must be made of the mixed pressure turbine, which has played a prominent part in the past. This type of turbine has rendered excellent services in connection with steam-



Large Gas Engines at an Iron Works

Galloways Ltd.

driven winders and rolling-mills, utilising from these engines the exhaust steam, which when exhausted to atmosphere would have constituted an appalling waste. The growing centralisation of power production in collieries and steelworks in parallel with the electrification of the entire plant tends to lessen the field of application of the mixed pressure turbine.

Reducing Turbines

A further type of turbine which in recent years has moved to the foreground is the reducing or pass-out turbine. This class is arranged automatically to bleed steam at a certain pressure for process work, mainly in paper mills, oil factories, distilleries, etc., or for heating purposes. The turbine utilises the pressure energy of the steam between the boiler and pass-out pressure, which would be entirely lost if the steam for process work were tapped directly from the boilers through a reducing valve. When large quantities of low-pressure steam are required, as for instance in paper-mills, the saving in coal consumption with a pass-out turbine is very considerable.

Actual test results of impulse turbines of the high pressure, mixed pressure, and reducing type are given in Table I., A, B, C, D, and E. Table II. illustrates steam consumptions that may be reasonably expected with turbines designed for high steam conditions as would now be recommended for new plant.

Turbo-Compressors

The extensive application of compressed air in pneumatic tools for mining operations, for coal cutting, for riveting in shipyards, etc., has prepared the field for the advent of the turbo-compressor. One of the largest compressors built in England has a normal capacity of 30,000 cubic feet of air per minute, compressing this quantity against 100 lbs. per sq. in. (G) Table I. (F) gives results of a test upon a compressor of 20,000 cu. ft. capacity, 100 lbs. per sq. in., delivery pressure. The air pressure usually required for the above mentioned purpose varies between 60 and 120 lbs. per sq. in., according to the type of pneumatic tools used, and to the length of the distributing pipe lines. It is difficult to fix a limit for the maximum quantity that can be conveniently dealt with by a turbo-compressor. On the Continent compressors have

TABLE I.

TEST RESULTS OF FRASER-CHALMERS RATEAU-TYPE STEAM TURBINES UNDER ACTUAL WORKING CONDITIONS.

Ref.	Type of Turbine.	Size in K.W.	Speed in R.P.M.	Steam Pressure. Lb./Sq." G.	Super-heat in ° F.	Vac. at 30" Bar. „ Hg.	Test Load in K.W.	Steam Consumption in Lb./k.w. Hr.
A	High pressure.	3750	3000	160	150	1[illegible]	3728	13.48
B	„ „	5000	1500	175	123	27¼	5000	14.05
C	„ „	5600	1800	140	100	28¼	5600	14.45
D	Mixed pressure	1000	3000	H.P. 160	150	28¼	940	14.60
				L.P. 16 abs.	D.S.	28	979	29.35
E	Reducing	1950	3600/120	150	150	28	1575	15.45 Cond. all steam.
				150	150	28	96	26.35 Passing out 15,000 lbs. per hr. at 10 lbs. per sq. in.
F	*Turbo Compressor* High pressure	20,000 cu. ft. of air per min. at 60 deg. F. 30" Bar. against 100 lbs. per sq. in. G.	2850	100	96	28¼	lbs./hr. 37,700	
G	*Tubo-Blower* High pressure	3500 cu. ft. of air per min. at 60 deg. F. 30" Bar, against 20 lbs. per sq. in. G.	3100	160	150	27¼	lbs./hr. 32,900	Non-cooled blower.

TABLE II.

STEAM CONSUMPTION OF FRASER-CHALMERS RATEAU-TYPE STEAM TURBINES UNDER IMPROVED STEAM CONDITIONS.

Ref.	Type of Turbine.	Size in K.W.	Speed R.P.M.	Steam Pressure in Lbs. per sq. in.	Total Temp., ° F.	Vac. at 30" Bar. „ Hg.	Steam Consumption in lbs. per hour.
A	H.P.	5000	3000	300	700	28¼	10.35
B	H.P.	3000	3000	300	700	28¼	10.7
C	H.P.	1000	6000	250	650	28¼	12.1 geared.

Author's Note.—It remains to be proved in industrial practise whether the high pressures and superheat required to obtain these low steam consumptions are not out balanced by maintenance cost on boilers, steam ranges, and turbines.

METROPOLITAN-VICKERS STEAM TURBINES. (RATEAU TYPE.)
(Test results under actual working conditions.)

Type of Turbine.	Size in K.W.	R.P.M.	Steam Pressure, Lbs. per sq. in. G.	Super-heat. deg. F.	Vacuum Hg.	Test Load in K.W.	Actual Consumption in Lbs. per k.w.Hr.
High pressure ..	5000	3000	170	125	28.5	5473	13.4
„ „	5000	3000	100	100	2.85	5500	13.35
„ „	3000	3000	180	200	28.5	3000	12.57
„ „	3000	3000	160	120	27.5	2992	14.38
„ „	2000	3000	160	160	28.0	2015	13.9
Mixed pressure ..		3000	H.P. 160	150	28.1	1450	15.4
„ „	1500	500	L.P. 16 abs.	dry	27.5	..	..
„ „	1000	2500	H.P. 150	150	27.85	991	16.1
„ „			L.P. 16 abs.		27.75	680	32.0
Reducing pressure	1[illegible]00	3000	200	dry	28¼	1000	16.79

When passing 30,000 lbs. per hour to heaters at 60 lbs. per sq. in. G. steam consumption when developing 1000 k.w. measured 32.7.

RUNNING COSTS OF SULZER-DIESEL ENGINES, 2,000 B.H.P.
(Period January to October, 1922).

	£	s.	d.	
(1) 1714 tons of fuel oil at £5 10s. per ton	9,440	0	0	(0.816d.)
(2) 17.27 tons of lubricating oil at 4s. per gallon ...	860	0	0	(0.029d.)
(3) 0.628 tons of cotton waste at 53s. per cwt. ...	33	10	0	(0.001d.)
(4) Attendance—1 chief mechanic, say	335	0	0	(0.011d.)
(5) Five men at £4 per week each for 40 weeks ...	800	0	0	(0.027d.)
Total	£11,468	10	0	(0.384d.) Per B.H.P. hour.

recently been built for 40,000 cu. ft. air volume.

Turbo-Blowers

Turbo-blowers and turbo-compressors are in principle one and the same thing, the name turbo-blower relating to machines working against moderate air pressures, say up to 40 lbs. per sq. in. From the engineering point of view there is hardly an upper limit, within reason, for air quantities that can be handled by turbo-type blowers, the limit being drawn by economic considerations. A common size is the 35,000 cu. ft. blower. Anything above will rapidly increase the first cost without appreciably improving the running economy. The superiority of the turbo-blower and compressor over the reciprocator is similar to the position the steam-turbine occupies in relation to the steam-engine; reliability in operation, low cost of upkeep, and small floor space required are the prominent features of the turbo-blowers.

Condensers

Table 1. (G) gives a test result of a typical blast-furnace blower.

With reciprocating engines little or nothing can be gained in steam economy by the installation of condensers to give more than 26 inch Hg. vacuum with Bar, at 30 ins., but this does not apply to steam turbines with which the highest obtainable vacuum can be fully utilised.

The requirement of the maintenance of a high vacuum, with turbines, has been met by the designers and makers of condensers and of auxiliaries for these, and recent improvements in the designs and efficiencies of centrifugal water-circulating pumps have been of great assistance in the economical operation of high vacua condensers.

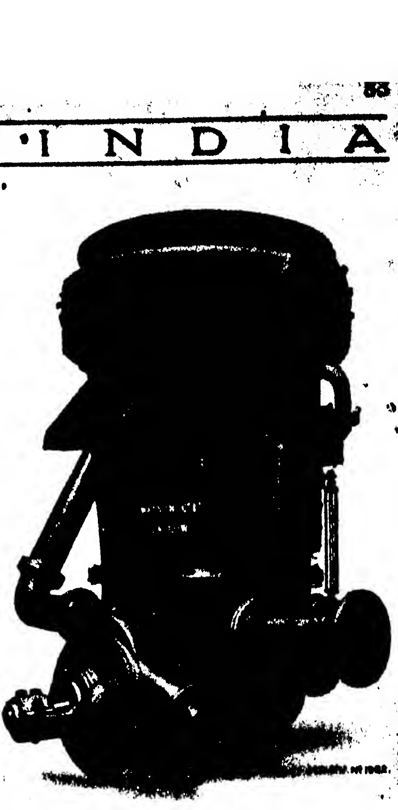
The available types of condensers may be classed under three main heads, viz.:

(1) Surface condensers.

(2) Jet condensers with water extraction pumps and separate air pumps or other air extraction appliances.

(3) Ejector condensers with water-circulating pumps and no separate air pumps.

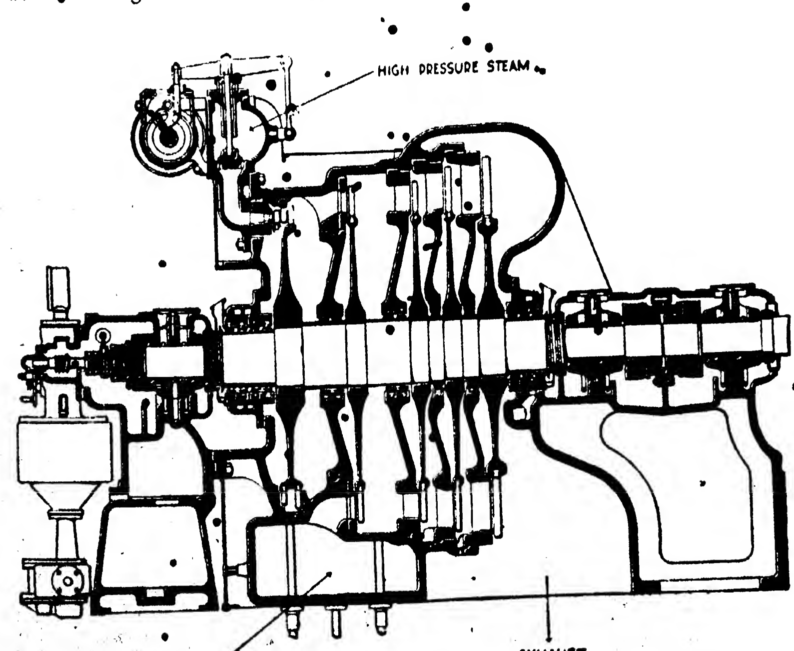
With surface condensers the condensed steam can be used for the boilers, and this has often led to their adoption where suitable water for boiler feeding was not available. Surface condensers are high in first cost, and their adoption may materially increase the cost of power station buildings. The use of condensers of this type, where clean condensing water cannot be obtained, necessitates troublesome and costly



Low Level Jet Condenser — *The Mirrlees Watson Company Ltd.*

cleaning of tubes and periodical renewal of these.

The modern method of dealing with boiler feed water by heat and soda ash, has extended the application of condensers of the jet, or ejector types, with the advantages of reduced capital outlay, lower maintenance charges, and continuity of service.



Section through impulse type Steam Turbine

Water Cooling Plants

Only in few cases will it be found where industrial sites are in proximity to a natural and adequate supply of water for condensing. This is not a serious disability as, with a loss by evaporation of about 80 per cent. of the boiler feed, the condensing water can be re-used after cooling in towers or by spraying over ponds.

For high vacuum plants with artificial cooling the ratio of condensing water to the steam condensed should not be less than 60 : 1, this giving a maximum requirement of temperature reduction of 10 deg. F. for the cooling installations.

The area required for cooling towers is 0.8 to 1 sq. ft., and for spray cooling plants 4 to 5 sq. ft. per kilowatt of plant installed. Where space is available, spray cooling should be adopted in preference to tower cooling, as the first cost is lower and better cooling is obtained with sprays. The maintenance charges with spray cool-

ing plants are negligible, whereas with cooling towers the cover for maintenance and depreciation may be a heavy charge.

Space does not permit of more than cursory treatment of condensing and cooling problems, but that requirements can be satisfactorily met is shown by the following results obtained with an installation of ejector condensers with spray cooling plants, say for 3,000 k.w. turbo-alternators, installed at a colliery power station. With these plants 28-in. Hg. vacuum is obtained with Bar 30 in. with the turbo-alternators giving full output.

The plants are simple, as for each turbine unit it is only necessary to operate two centrifugal pumps driven by one motor. The efficiency is high, as the current consumption for the motors is less than 3 per cent. of the full load outputs of the turbo-alternators.

In the same power station the pumps for similar condensing and cooling equipments are driven by a high-speed engine, and as the exhaust steam from this is used for heating boiler feed water the operating costs are very low, and there is the advantage that no deduction has to be made from the output available from the turbo-alternator, as is the case with the motor-driven units.

Example of a Typical Industrial Power Station

It may be of interest at this stage to give a description in detail of a typical industrial power station, and for the purpose of illustration the author has taken the actual case of a colliery power station in this country.

This power station was erected for the purpose of supplying electric power to a group of collieries principally for underground power, such as pumping, hauling, coal cutting, and general purposes, and also for main shaft winding. The system of supply, which was settled as far back as 1907, was 3,000 volts, three-phase, 50 cycles. The rapid power development since 1907, was such that the laying down of a large central station became imperative for the requirements of the area.

The station equipment comprises at present one 1,500 k.w. turbo-alternator and two 3,000 k.w. turbo-alternators.

The condensing plant is of the multi-jet type, and the whole of the water required for condenser purposes is re-cooled through spray nozzles. It is possible to maintain a vacuum of 28 ins. under full load conditions in the large units with barometer at 30 ins.

The boiler plant comprises six large boilers of the water-tube type, each capable of evaporating 22,000 to 27,000 lbs. of steam per hour. The steam pressure adopted is 200 lb. per square inch, with superheat to a total temperature of 588 deg. F.

The condenser equipments are all joined together, and any of the three circulating pump equipments in the station will operate any of the condensers.

No. 1 condenser is operated by a steam engine, the other two by motors. There is also a steam-driven exciter and a motor-driven exciter, the latter of full capacity for all the units in the station. The exhaust steam from the condenser and exciter engines, feed pumps, and fan engines is used for heating up the feed water. The feed water is treated in a heater softener by the temperature and soda ash method.

The Erith retort stokers are each of the seven retort type, and are capable of burning approximately 434 lb. of low grade fuel per hour. The first four stokers are operated by electric motor, but the fifth and sixth are operated by steam, it being considered desirable to have some of the boiler plant operated entirely by steam and independent of the electric station. It will be noted that each pair of boilers is fitted with one induced draft fan and short chimney. The coal is tipped direct from wagons into the coal-pit shown under the railway. Hydraulic wagon tippers are used, one being placed at each end, to enable wagons to be handled without being turned on a turn-table. The coal is elevated from the dross tip to the large bunker alongside the boiler-house. Each boiler is fitted with an independent elevator, and all elevators are separately driven.

It is interesting to note that saturated steam is used for the small engines, principally because of the greater value of saturated over super heated steam for feed water heating. The steam and feed pipes are arranged on the "ring" system with isolating valves at suitable points. The ashes are taken direct from a hopper situated underneath the grates. The boiler-house floor is raised 10 ft. 6 ins. above ground level to admit of this. The ashes are tipped direct into hoppers and conveyed by rail up an incline frame into the overhead bunker for tipping into wagons.

The main switchboard control panels are placed on the power-house floor level, and the cubicles containing the high tension apparatus are placed on a floor above the condenser house. The complete arrangement is compact and easily worked.

The following figures taken from the station records are interesting with 13,000 k.w. unit running:

Units generated per week	416,950	
Load factor ...	82.6 per cent.	
Wages costs ...	0.042d.	per unit.
Coal costs	0.178d.	,, ,,
Oil and stores ...	0.011d.	,, ,,
Total production cost	0.231d.	,, ,,

The fuel was charged at approximately 11s. 7d. per ton, and it should be noted that with low grade fuel charged, as is possible in many cases, at 5s. per ton at the colliery, the fuel cost would be reduced to 0.077d. per unit, and the cost of production would then become 0.13d. per unit.

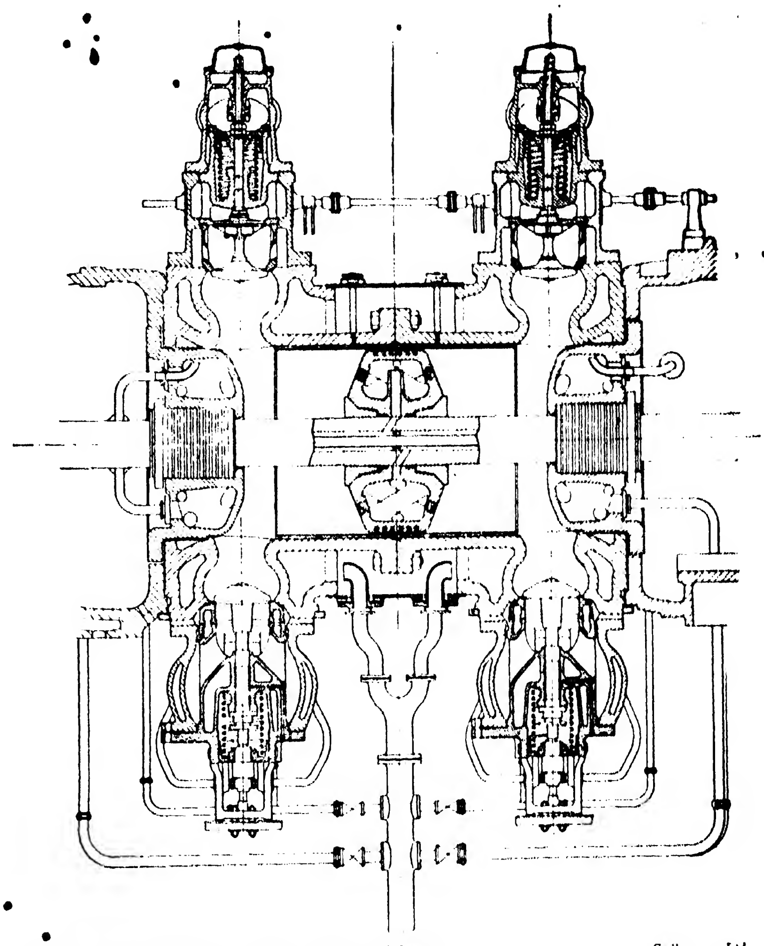
Gas Engines

It is not possible within the scope of this paper to deal adequately with the important developments which have taken place during recent years, in the direct application of blast-furnace, coke-oven, and producer gas for the operation of high-powered gas-engines, but the author feels that his paper on Power Production would not be complete without some reference, however brief, to this important subject. Single installations of from 15,000 to 20,000 horse-power of gas-engines working upon blast-furnace gas are already in operation in England.

In a paper road by Mr. P. H. Fowles, before the Institution of Electrical Engineers in 1920, upon the "Production of Power from Blast-furnace Gas," some valuable and interesting data are given. In the case of a modern furnace producing one million cu. ft. of gas per hour, only 0.55 of this is required for the furnace, leaving 0.45 million, or 450,000 cu. ft. of gas available per furnace for other purposes, and this at 150 cu. ft. per kilowatt-hour is equal to about 3,000 units of electricity per furnace per hour. With fifty furnaces the aggregate would

equal 150,000 units saved per hour, and 1,030,510 per annum: this with the boiler saving represents an economy of about 400,000 tons of coal per annum.

By cleaning and using blast-furnace gas efficiently, remarkable savings can be effected. It will be seen, therefore, that an immense amount of surplus power is actually available from waste gases from the blast-furnaces in England, and after the needs of the works themselves have been satisfied the surplus power can, with advantage, be directed towards the supply of power to other industries, or fed into the network of power supply companies' systems.



Section through large Gas Engine Cylinder and Valves — *Galloways Ltd.*

A process for seasoning timber by means of ozone has been developed at the Sorbonne, Paris, by Professor Otto, and is claimed to give results in twenty days equal to those obtained naturally in several years. The process consists simply in exposing the wood to a current of ozone-charged air. The colour remains unchanged, and microscopic examination is reported to have shown that ozone-dried oak and walnut had the same characteristics as ordinary air-seasoned wood. The experiment seems to have reached the commercial stage, as Italian and French companies are, it is said, arranging to work the process.

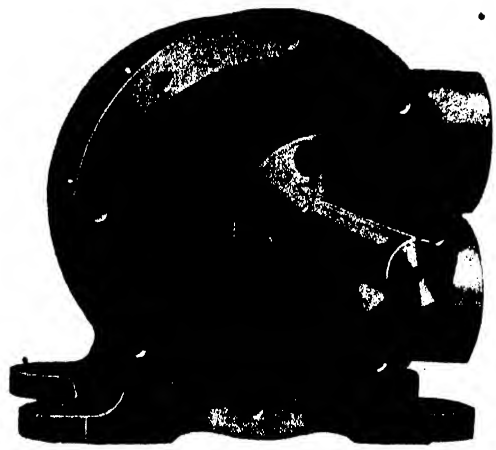
The New Kitson-Utley Rotary Pump

THIS invention relates to Rotary Pumps, Engines and Meters of the type wherein a circular rotor is set eccentrically in a drum-shaped blade-chamber, the outer periphery of the rotor being in contact with the inner periphery of the blade-chamber, and a double-ended sliding blade is mounted in the rotor, so that it can slide through the centre of the same, whilst its ends sweep the walls of the chamber.

Many attempts have been made to make pumps and engines of this description, some of which were operated by having the blade divided and connected with springs so as to force the ends of the blades in contact with the cylinder. In such cases the cylinder has been of the ordinary circular type, the results being that the chamber has been readily worn away by the pressure of the springs acting on the blades.

The object of the present invention has been to provide a rotary pump, or motor whose blade-chamber is so shaped that the ends of the blades are always accurately in contact with the walls of the chamber without using any spring-controlled portions.

In the present invention the blade-chamber is so shaped that for any angular displacement of the blade an endwise displacement of the same takes place, which is proportional to the square of the said angular displacement measured from the point



Interior view of Kitson-Utley Pump

where the rotor touches the chamber wall. The shape of this chamber may be obtained by causing the walls swept by the ends of the blade to conform to an endless curve which touches the periphery of the rotor at one point, and is traced from this first point through points plotted on lines radiating from the centre of the rotor, each of which points is distant from the periphery of the rotor by a length along its radius proportional to the square of the fraction expressed by the ratio of the angle between such radius, and the first-mentioned point divided by 90 deg., and also is further proportional to half the maximum endwise travel of the slide.

It will be found that, with a blade-chamber so shaped, straight lines drawn from any point on the inner periphery of the chamber, through the centre of the rotor to meet the inner periphery of the chamber on the opposite side will all be of equal length, and thus a blade of this length will always have its ends in contact with the walls of the chamber throughout the whole of its angular movement.

It will be seen that for every variation of the ratio of the diameter of the rotor to that of the chamber, the shape of the curve is altered. Further the limit at which the curve becomes finite is when the rotor is half of the diameter of the cylinder. This construction provides a means for obtaining continuous acceleration. The pump has only two working parts, and has neither springs nor valves, and as the rotor revolves the blade oscillates to and fro through the centre of the rotor. The pump lifts and drives on the same stroke, and the pump will raise a given quantity of water to any height limited only by the power applied, and the bursting limit of the casing. The pump is now being used for pumping fluids of various consistencies from petrol to margarine.

The size shown in the illustration has 1¼ ins. outlet and the size of the cylinder is 4 ins. diameter. The weight in gunmetal is only 23 lbs., but will deliver 1/5th gallon at every revolution, so that at a speed of 200 revolutions per minute it will deliver 2,400 gallons per hour. The pump has also been used as an air exhauster, and at a speed of 750 revolutions per minute over 29 ins. has been reached on the vacuum mercury gauge. It has only been used experimentally as an air compressor, and so far the highest pressure that has been achieved was at a speed of 900 revolutions per minute, and reached 60 lbs. to the square inch. As the pump takes in a fixed quantity at each revolution it can be used as a meter for measuring the quantities delivered. It may be revolved in either direction, and under normal conditions no renewal parts are required. It will be seen that the cylinder has to be kept free from grit to avoid injuring the surface of the cylinder. Where dirty water that is liable to contain sand or grit is used a screen or filter is employed. The pump may be driven either by hand or by power. It will also be seen that the pump lends itself to use as a motor, and already it has been employed experimentally as a steam and compressed air motor.

The pump is manufactured by the Kitson Engineering Co. (London), Ltd., at their works, Stamford, Lincolnshire.

Outside view of Kitson-Utley Pump

Lignite and Brown Coals

Under the above title Professor William Arthur Bone, D.Sc., Ph.D., F.R.S., read a paper before the Indian Section of the Royal Society of Arts, dealing in a very full manner with the origin and classification of Brown Coals and Lignites. Space will not admit of reproducing this interesting paper, but we give below a full report of Professor Bone's general observation on the utilisation of these particulars coals, in which is recorded details of some very interesting developments which are taking place in the more efficient use of Lignites as a result of recent experimental research.

FOR some years past I have been investigating brown coals and lignites, chiefly from a chemical standpoint, with a view to extending our knowledge of their behaviour on carbonisation at various temperatures, and of the character and amounts of the various by-products obtainable from them, and to finding out possible ways of overcoming some of their obvious drawbacks as gas producer and steam raising fuels. Some attention has also been paid to the technical possibilities of manufacturing smokeless domestic and steam fuels, as well as cokes suitable for metallurgical purposes, from the carbonaceous residue left in the retorts after carbonisation. A mass of useful data has thus been accumulated, which I hope may some day be collected in a handy form for publication; but I fear it is impossible to compress them within the limits of the present paper. I must, therefore, content myself with a few general observations on the foregoings points, after which I propose to deal in detail with the practical outcome of some new experiments made with a view to enhancing the fuel-values of brown coals and lignites for steam raising purposes.

Preliminary Drying

From what has already been said in the earlier section of this paper, I regard a preliminary drying operation as always very desirable, if not essential, to the economical utilisation of such fuels, either for steam raising or carbonisation purposes. Prolonged "air-drying" is usually capable of reducing the water content of the raw fuel down to about 15 per cent.; but such a process is too dependent upon climatic conditions, and, moreover, takes too much time, to be generally practicable on a large scale. Consequently, other means must generally be resorted to, and it is obvious that they should, whenever possible, involve the utilisation of some convenient form of "waste-heat," such as either exhaust steam or the products of combustion from boiler furnaces, retort settings, or the like.

It can easily be shewn by calculation, that if a *dried* lignite be burnt under boilers, there is vastly more available heat in the gases leaving the boiler at, say, a temperature of 400 deg. C., than would be required to completely dry the raw fuel, even if it contained as much as 50 per cent. of water. But, owing to the readiness with which dry lignites ignite, as well as to the tendency of the raw fuels to disintegrate on being dried, the problem of successfully applying the "hot chimney gases" is not without its difficulties. Our experiments have, however, shewn that such gases can generally be employed safely for the purpose, provided that they contain more than 10 per cent. of carbon dioxide, which condition should not be difficult to regular attainment on large boiler installations where the scientific control of combustion is carried out.

Provided, then, the brown coal or lignite has been previously dried, the problem of carbonising it at any particular temperature will usually be of no greater complexity than it would be in the case of a rather low grade non-coking bituminous coal, always allowing for the circumstances that brown coals and lignites are devoid of coking properties, and that their carbonised "residues" ignite more readily than would coke if allowed, whilst hot from the retort, to come into contact with air. Their residues may, however, be briquetted with suitable binding, making excellent domestic and steam raising fuels.

Compared with those usually obtained from bituminous coals, the gas-weight and liquor yields (referred to the *dry* coal) are generally higher although the gas contains an unusually large percentage of carbon dioxide, owing to the higher oxygen content of the coals. The gas would certainly have to undergo some "lime" purification process for the elimination of its carbon dioxide before it would be suitable for public distribution; and even then its content of carbon monoxide would be higher than I should like to see, although my good friends in the gas industry would probably view them with equanimity, if not with positive delight.

The question of the low temperature carbonisation of lignites is receiving attention in many quarters and is worthy of much further study. Some lignites that I have invested yield most valuable fuel and light oils, but time does not permit of my particularising.

Lignites in Producers

There is also no particular difficulty about gasifying lignites in producers, and with good results as far as the quality of gas is concerned. As an example I may here quote the results of such trials carried out by the Power Gas Corporation Ltd., upon French and Italian lignites in a Mond By-Product Peat Gas Producer Plant at Orentano:—

	French Lignite (from La Savoie).	Italian Lignite (Ribollo).
	%	%
Moisture in Coal charged ...	40.5	8.5
The Dry Fuel contained:		
Fixed Carbon ...	33.9	—
Volatiles ...	50.1	—
Ash	17.7	16.2
Nitrogen ...	1.8	1.9

Yield of Gas : Cub. ft. at 15 deg. C. per ton Dry Fuel	78,300	71,700
Composition of the Gas :	%	%
CO_2	20.8	16.3
CO	10.6	11.5
H_2	25.6	26.3
CH_4	5.4	4.8
N_2	37.6	50.1
	100.0	100.0
Yield of Ammonium Sulphate in lbs. per ton of Dry Coal ...	92.5	130

Heat Treatment at Temperatures Below 400 deg. C. as a Possible Method of Enhancing their Fuel Values.

In the course of my researches upon brown coals and lignites, I had occasion to study their behaviour when, after being previously completely dried at 100 deg. C., they were further heated, out of contact with air, in a special form of apparatus which permitted both an easy control of the temperature condition, and the accurate measurement of any liquid or gaseous products that might be evolved.

Morwell Brown Coal

In my first experiments on such lines, which were made upon the Morwell brown coal already referred to, some highly significant observations were made, which subsequent research has proved to be characteristic of brown coals and lignites generally. The detailed results of these researches having already been published about a year ago in the proceedings of the Royal Society, A. Vol. 99 (1921), I need now describe them in outline only, with some additional information concerning the practical developments which have since flowed therefrom.

It was found with the dried Morwell coal that, beginning at as low a temperature as 130 deg. C., but principally between 250 and 357 deg. C., a chemical condensation occurred, affecting the cellulosic or humic constituents thereof, which was characterised by the simultaneous elimination of both steam and carbon dioxide from the coal substance itself, without any appearance of oils or more than a quite negligible amount of gaseous hydrocarbons.

Thus, in a typical experiment, when the temperature of 100 parts by weight of the dried coal was slowly raised to, and then maintained at 375 deg. C., until no further change occurred, there was eliminated 5.5 parts of water and 6.6 parts by weight of gas (1427 cub. ft. per ton of the dry coal), which latter contained :— H_2S = 1.5, CO_2 88.5, CO 4.1, CH_4 1.1 and N_2 4.8 per cent.

It was thus clear that the said heat treatment had brought about a chemical condensation in the coal substance itself, possibly comparable with that by which, deep down in the bowels of the earth, our present bituminous coals, in the course of long ages, have been slowly produced from pre-existing brown coals. Such condensations had involved a marked elimination of oxygen (as both steam and carbon dioxide) from the coal substance, with consequent considerable weight loss (amounting to one-eighth of the original) and marked increases both in the percentage of carbon content and calorific value.

The percentage composition and calorific value of the dry coal treated, and of the "residual coal" obtained were as follows :—

	Dry Coal treated.	Residual Coal.
Carbon	62.50	68.5
Hydrogen ...	4.85	4.9
N. and S. ...	0.65	0.8
Oxygen	28.00	21.2
Ash	4.00	4.6
	100.00	100.00
Gross Calorific K.C.Us. per Kg.	5600	6360

The chemical and thermal balances of the experiment were as follows :

	100 Parts of the dry coal containing Parts.	yielded
Carbon	62.50	$5.5H_2O$
Hydrogen ...	4.85	$6.5CO_2$
Oxygen	28.00	
K.C.Us. ...	560,000	

87.6 Parts of Residual Coal containing Parts.	Loss Parts.
60.00	2.50
4.30	0.55
18.55	9.45
558,000	2,000

It will thus be seen that whilst the dry coal had lost about one-eight of its orginal weight, it had retained practically the whole of its potential heating power, but in a more concentrated form. The weight loss had amounted to about one-third of the oxygen, one-tenth of the hydrogen, but only one-thirtieth of the carbon originally present in the coal substance a very remarkable result.

Characteristics of Brown Coal

Subsequent research showed that such behaviour on similar "heat treatment" is characteristic of brown coals and lignites as a class, and that such treatment affords a ready means of "up-grading" such coals, and of improving their fuel values generally.

At this juncture I got in touch with Mr. W. R. Wood, General Manager of the Underfeed Stoker Co., London, who had had considerable experience in burning such low grade fuels under boilers ; and I put before him the idea not only of *drying*, but also at the same time of "*up-grading*" the fuel values of brown coals and lignites by further heat treatment in the aforesaid manner, in one continuous operation, using no other energy than would be comprised in the sensible heat in the burnt gases passing away from either a boiler or a retort setting. In other words, I proposed to utilise the "waste heat" of the chimney gases (assuming them to contain more than 10 per cent. of carbon dioxide and to leave the boiler at a temperature of 400 deg. C. or more) for the purpose firstly of *drying* the raw lignite, and secondly of "*up-grading*" the dried fuel in one continuous operation, before it reaches the boiler furnace.

Mr. Wood at once saw the advantages of such a proposal, and thought it was quite a practicable one ; and, at his suggestion the Underfeed Stoker Co. undertook to see what could be done to give effect to it in practise. Ultimately they designed and patented an apparatus for the purpose, capable of being attached to a water-tube boiler. For want of a better name, I will, for the present, call it the "fuel improver" attachment, because it is designed to effect the double purpose of drying and up-grading the ingoing raw fuel at the expense of part of the heat of the outgoing products of its combustion The following diagram shows the general arrangement of a watertube boiler with mechanical stoker fitted

with one of such attachments as designed by the Underfeed Stoker Co., which has been installed by the Victorian Government Electricity Commissioners at Morwell, and is now undergoing systematic trials there under the supervision of Mr. H. R. Harper, their Chief Engineer.

The "Fuel Improver"

The boiler is of the Babcock Wilson type, and is fitted with a self-contained forced-draught travelling grate stoker; the heating surface of the boiler is 2,436 sq. ft. and the grate area is 85.7 sq. ft. The "fuel-improver" attachment is constructed of a sheet iron casing, made practically air-tight, and is fitted with two parallel series of cast-iron plates, which are sloped at an angle of about 80 deg., with the horizontal so as to form a chute with open sides, the plates being arranged in the form of louvres.

The raw coal is automatically fed into the top of the chute, and in slowly passing down it encounters a directed flow of the hot products of combustion from the boiler setting, whereby it is first of all dried and afterwards "up-graded" in accordance with the plan already described. In this particular installation it should be observed that the hot gases as they leave the boiler come in contact first of all with the raw incoming fuel; in other words, the relative passages of the fuel and gases through the apparatus is not on the contra-flow principle. As orginally designed, it was intended that they should be on that principle; but it was afterwards thought better in this first trial unit to depart from it, because there would be less likelihood of the fuel becoming ignited during its passage down the chute if the gases met the raw fuel with its maximum water content at their highest temperature. It is hoped, however, that the result of these trials will shew this to be an unnecessary precaution, in which case the contra-flow principle will be adopted in future installations. The chute is capable of containing about 2.1 tons of raw fuel, which at the present rate of operating takes about 45 minutes in passing through the apparatus.

One of the principal advantages which it is expected will be gained by the use of such a "fuel-improver" in connection with big power-station boiler installations, such as the one contemplated at Morwell, where a low-grade but cheap, brown coal must be used, is that by so drying and "up-grading" the fuel, before it is burnt in the boiler grate, will give a much hotter and more radiant fire than it would otherwise do, with consequent increase in both the steam output per boiler and the thermal efficiency of the system as a whole. In other words, it is confidently anticipated that, owing to the higher furnace temperature which will certainly be realised when such a fuel-improving arrangement is employed, the rate of heat transmission throughout the boiler will be greatly improved. Indeed in submitting their scheme for the Morwell contract, the Underfeed Stoker Co. guaranteed that nine boilers filled with their new "fuel improver" attachment would give the same steam output as twelve boilers fired with the untreated fuel, and with a greater thermal efficiency.

As the trials of the apparatus are not yet completed, it would be premature for me to attempt in this paper to pass any final judgment thereon. But judging from the results which have so far been reported to me, I am able to say that it seems probable that the anticipations of the Underfeed Stoker Company will be more than fulfilled when the final results are known. For it has already been proved that, after passing through the "fuel improver" attachment to the boiler, the fuel burns very freely and can be efficiently consumed at high rates of combustion; also that the treatment of the fuel brings about a marked increase, both in the furnace temperatures and in the rate of heat transmission throughout the boiler.

Results of Tests

Thus, for example :—

(1) In a trial carried out on 6th October, last, in which the *raw fuel was burnt without being passed through the "fuel improver" attachment*, the rate of combustion in the grate was 34.9 lbs. per hour, and the water evaporated 6,550 lbs. per hour. The furnace temperature was 928 deg. C. (1,702 Fahr.); and the products of combustion leaving the boiler at 292 deg.C. (577.7 deg. Fahr.) contained CO_2=10.3, CO=1.7, and O_2 =7.4 per cent.

(2) In a similar trial, carried out on the following day, *in which the same fuel was passed through the "fuel improver" attachment*, the rate of combustion was 94.05 lbs. per sq. ft. of grate per hour, and the water evaporated was 20,200 lbs. per hour, the furnace temperature was 1,149 deg. C. (2,100 deg. Fahr.); and the products of combustion leaving the boiler at 315 deg. C. (599 deg. Fahr.), but the "fuel improver" attachment at 92 deg. C. (198 deg. Fahr.), contained CO_2= 13.5 CO=0.33, and O_2=5.6 per cent.

The foregoing figures are quoted just as they have been reported to me, but it is to be understood that they represent the results of two quite preliminary trials only, and that no finality is here claimed for them. I am hoping soon to receive reports of further and more exhautive trials, until which time I shall prudently reserve any final expression of opinion.

The Trans-Zambesia Railway Opened

The Trans-Zambesia Railway, to which we have previously referred in these columns, was officially opened on July 1st. This new line puts the Union of South Africa in direct communication with Nyasaland, and is an important link in the chain of new and projected railways, having for their object the development of South Central Africa, the ocean terminus for which territory is Beira. The new line runs from Dondo, a junction on the Beira—Mashonaland Railway, eighteen miles from Beira, to the Zambesi River, and is 157 miles long. The contract price for the line was £810,000. An early development is expected to be the construction of feeder lines to tap the Tete coalfields. It is of interest to note that the Nyasaland Government has guaranteed for a period of twenty-five years the interest on the debentures issued and the redemption fund. The Trans-Zambesia Railway Company was formed in 1920, with a capital of £600,000, while debentures were underwritten to the extent of £1,200,000, for the construction and equipment of the line.

QUESTIONS & ANSWERS

We shall be pleased to answer any question relating to industry, to advise in the starting of any particular branch of manufacture, to give expert advice on any power or power transmission problem, or to render any assistance possible in solving mechanical or technical problems. All questions should be addressed to the Editor, London

QUESTION.

To The Editor "Industrial India."

Re FUEL ECONOMY.

DEAR SIR,—With reference to the April number of the INDUSTRIAL INDIA, we are much interested in produce of plant for wood distillation known as the Wells system as illustrated in your issue on page 465. So we will be obliged if you will please furnish us with the addresses of the manufacturers of such plants.

We are also interested in power plant of fire boilers with gas burners, and we shall be glad if you will also send us the addresses of the manufacturers of these burners with power plant for use in Lancashire boilers.

ANSWER.

DEAR SIR.—Replying to your letter which has been forwarded to us from our Bombay Office, in which you ask for the names and addresses of the firms making the "Wells Gas Producer" and also gas burners referred to in the April issue of INDUSTRIAL INDIA we have pleasure in giving this information as follows: (1) The Wells Gas Producer, Messrs. Wells Vegetable Fuel Power Co. Ltd., 39 Grosvenor Place. London, S.W.1.; (2) Gas burners, Messrs. The Power Gas Economy Co., 50 Wellington Street, Glasgow.

We have written both the above firms asking them to send you particulars of their manufactures in order to save time.

QUESTION.

To Editor "Industrial India."

SIR.—I want to start stamping of cups, saucers, etc., from brass sheets. Will you be so good as to inform me the name of the firm where I can get the necessary machinery, worked by hand power, and also worked by a small internal engine, it might be more economical to work by hand in the beginning.

Can I get a book on the technique of the business.

What will be the amount needed to start the business? Could you send me the price list, etc. I am rather keen on starting a business at an early date.

ANSWER.

DEAR SIR.—Replying to your letter in which you state that you want to start the stamping of cups and saucers, etc., from brass sheets, and asking us for information regarding the machinery for such manufacture.

If you refer to the July issue of INDUSTRIAL INDIA, you will find that we have given the names and addresses of several manufacturers of presses suitable for your proposed work and in order to save time we have asked each of these firms to send you direct, copies of their catalogues and any other information which they consider may be helpful to you.

Regarding a technical book on the subject we would refer you to the book which we recently reviewed in the April issue of INDUSTRIAL INDIA on page 502, entitled "Die Making and Die Designs," published by the Industrial Press, New York, London Office, Machinery Publishing Co. Ltd. Price 16s.

QUESTION.

The Editor, "Industrial India."

DEAR SIR,—Having read Vol. 1 No. 8, March, 1922, I would thank you to send me the name and address of the writer of "The Electric Furnace in Metallurgy," p. 420, as I wish to get certain advice from the writer.

I would further thank you to send me the addresses of one or two good companies, who make Electric Steel Furnaces.

ANSWER.

We have sent copy of our correspondent's letter to our contributor, who replies as follows:—

87 FITZWILLIAM ST.,
HUDDERSFIELD,
June 16th, 1922.

DEAR SIR, "I am very happy to be of use to you in any way arising out of my articles on Electric Furnaces in the March and April issues of INDUSTRIAL INDIA. I shall be very pleased to give you any advice or information, which comes within the scope of my experience with this class of melting furnace."

The makers of electric steel furnaces in this country, whose furnaces I can recommend from personal experience are:—Electro Metals Ltd., 56 Kingsway, London, W.C.2.; T. H. Watson & Co. Ltd., Lancaster Street, Neepsend, Sheffield. ("Greaves-Etchells" Furnace).

Of the American furnaces, I can particularly recommend that made by:—The Booth Electric Furnace Co., 326 West Madison Street, Chicago, Ill., U.S.A.

There are many other excellent furnaces on the market.

In settling choice of a furnace for any particular work, the following data will be required:—

Product.—Whether steel castings, ingots, plain or alloy steels, and average analysis.

Scrap Available.—Analysis.

Production Desired.—Tonnage of metal inclusive of necessary scrap (ingot tops, gates, risers, etc.), hours operated per day.

Main Power Supply.—Voltage, cycles, phases.

Auxiliary Power Supply.—Whether D.C. or A.C. voltage (if A.C. also cycles and phases.)

I trust that you will make the fullest possible use of me if you desire to go further into the matter."

Yours faithfully,

F. ROWLINSON.

ORGANISATION

Conducted by HARTLAND SEYMOUR

THIS SECTION DEALS WITH WORKS MANAGEMENT AND ORGANISATION, THE TRAINING AND WELFARE OF THE WORKERS, AND WITH THE ADVERTISING, SELLING AND MARKETING OF GOODS

Welfare Conference

The Department of Industries have sent us particulars of the above conference, at which a large number of papers were read, covering the whole field of welfare work. We give below a short account of the conference prepared by Miss G. M. Broughton, and we also put on record the resolutions passed at the conference.

MISS BROUGHTON states that this conference, the first of its kind to be held in India, was organized by the Currimbhoy Ebrahim and the Tata Sons Workmen's Institutes of the Social Service League, Bombay, and was held in Bombay on the 6th, 7th and 8th April. About 50 representatives from different parts of India were present, the Government of India and six local Governments sending 20 delegates. Men and women actually engaged in welfare work in connection with factories, such as the Buckingham and Carnatic Mills, Madras; Empress Mills, Nagpur; British India Corporation, Cawnpore, also attended. Social organizations such as the Young Men's Christian Association, Young Women's Christian Association and Servants of India Society were also represented, together with organizers of infant welfare work and members of co-operative societies.

Mr. Chatterjee, Secretary in the Department of Industries, was unanimously elected President. On taking the chair he found himself confronted with about 25 papers dealing with such heterogeneous subjects as infant welfare and the prevention of hook worm. The papers that had been prepared were first divided into two main groups, those dealing with work inside the factory and those with activities outside the factory. The conference then split up into two Committees to deal with each of these groups, Mr. Mehta, Director of Industries, being elected Chairman of the former, and Mr. Deodhar Chairman of the latter. Writers of each of the papers were asked to state their views briefly and to summarize them in the form of a resolution to be submitted to the general conference.

The subjects connected with inside factory welfare work, related to sanitation and hygiene, works committees, and the duties of welfare workers. Recommendations were passed on all of them. Questions of sanitation and hygiene, it was suggested, should be dealt with by Sanitary Officers of Government, who should be invested ex-officio with the powers of factory inspectors. The suggestion was also made that all factories should be required to maintain first aid appliances, and that employers should be encouraged to keep records of sickness among their workers. The recommendation on works committees was, as one delegate sagely remarked, sufficiently vague. Their establishment in factories was recommended, while at the same time the necessity of securing properly elected representatives of workers to serve on such committees was pointed out. As welfare workers *inside* factories are practically non-existent in India, the conference recommended that a start should be made by asking social service organizations to take up the training of welfare workers in co-operation with employers of labour and Universities.

Welfare work outside the factory embraced a larger range of subjects: education, child welfare, trade unionism, the spread of the co-operative movement and housing. The need of education was emphasized by urging that the Government, employers of labour and the public should be asked to co-operate to establish day schools, continuation classes and night schools in mill areas. Another resolution recommended the spread of the co-operative movement among factory workers. Infant welfare work was dealt with in a somewhat vauge recommendation. The great need of the provision of suitable housing for industrial workers was summarized in a business-like resolution, urging the formation of co-operative housing societies for skilled workmen and recommending that, in the case of unskilled workmen the Government, local authorities and employers should take immediate steps for the provision of suitable quarters sufficient for the number employed in that area. Two more recommendations, one relating to welfare work and trade unionism, the other to temperance, brought the sittings to a close.

The immediate practical outcome of the conference was the initiation of a central organisation for the promotion of welfare work. When completed the central organization will establish a permanent office for the collection and dissemination of information about welfare work. An executive committee will also be appointed to carry out the decisions of the conference, to supervise the work of the office, and to draw up the agenda for each conference. Further it is proposed that there should be an Annual General Conference consisting of (1) those who are actually doing welfare work; (2) representatives of organisations giving financial support to welfare activities; (3) representatives of Government departments concerned with the welfare of labour.

Those interested in the subjects discussed should be able to obtain the papers from the Secretary at the

Bombay Workmen's Institute, Elphinstone Road, Parel, Bombay. A complete report embodying all the resolutions will undoubtedly be printed in due course.

Sanitation and Hygiene.

(1) The general sense of the sub-committee is that managers will find it useful to maintain records of sickness and other causes of absence specially in cases where mill-hands live in quarters either belonging to the factory, or in close proximity to the factory.

(2) It is desirable that the sanitary officers of Government should also be invested ex-officio with the powers of factory inspectors, in order to enable them to investigate questions of health and sanitation inside the factories. It is also desirable that such sanitary officers should begin the investigation of causes and incidence of sickness in industrial areas and specially among factory workers. But they should issue no executive orders, except with the approval of the regular factory inspection department.

(3) A recommendation be made to the universities to include occupational, diseases and industrial hygiene as a post graduate study.

(4) It is suggested that in the rules framed under the Factories Act, all factories should be made to maintain first-aid appliances in the charge of qualified persons and that in factories of a small size some of the employees should be trained for the use of first-aid appliances.

Training of Welfare Workers.

It is the opinion of the conference that social service organizations be asked to take up the work of training welfare workers and that universities and employers of labour be asked to co-operate with these agencies.

Works Committee.

This conference is of opinion that works committees be established in all industrial establishments, and the functions of these committees be gradually widened. It is also the opinion of the committee that representatives of workers on these committees be appointed by some system of election by the workers.

Education of the Working Classes.

(*a*) With a view to secure better efficiency of working men, women and children, this conference urges the spread of education in suitable ways among these classes as a prime need of industrial employment, and for that purpose recommends the establishment in mill areas of day schools, continuation classes and night schools for imparting industrial or technical instruction and general culture, with the object of widening their outlook and rendering the workmen better workers, more intelligent factors in the country's industrial organization and more intelligent and capable citizens; in order to bring about such educational facilities, this conference calls upon the great employers of labour severally or jointly, the Government and the generous public to co-operate in this respect.

(*b*) In order to secure the proper development of the aptitude, and the capacity of the children employed, this conference considers that superintendents of welfare work should devote special attention to this aspect of the question.

(*c*) The conference is of opinion that in this connection the separate needs of half-timers, adult workers and the unemployed children of the mill population should be borne in mind as also the separate needs of boys and girls or men and women.

Co-operation among Factory Workers.

(1) This conference recognizes the necessity of an intensive propaganda for the promotion and success of co-operation among the working men in the industrial areas, and for this purpose, while appreciating the response made so far, urges employers of labour to contribute liberally to central co-operative or social work institutes existing in their respective localities.

(2) This conference recommends that mill-hands' societies should be organized preferably on locality basis rather than separately for each mill.

(3) This conference recommends that co-operative organizations should devote greater attention than at present to the encouragement of thrift, for example by introducing the system of regular monthly subscriptions and Saving Banks where possible.

(4) This conference recommends that the efforts of welfare workers outside the factories should be directed largely to the establishments of co-operative hostels, boarding houses and stores as supplying the primary needs of a good home and good food for all workers.

Maternity and Infant Welfare.

(1) This conference is of opinion that the foundation of all Medical Welfare Work depends upon an efficient midwifery service and the education of the mother, and that the best means to secure these objects should be considered by local committees, consisting of medical and social workers, with knowledge of local conditions, and that the recommendations of such committees should be submitted to the employers. The question of maternity clinics and homes must follow and should be arranged for according to the financial support given to the entire scheme by the various agencies already at work, and by the employers. Creches should be provided in every factory employing women.

Housing.

This conference wishes to emphasize the great need for the provision of suitable and sanitary houses for the workmen as a necessary condition for their industrial efficiency and general well-being.

For skilled workmen this conference recommends the formation of co-operative housing societies, with necessary help from employers of labour and from Government.

For unskilled workmen whose needs are exceedingly urgent this conference considers that in each industrial centre the Government, local authorities, such as District and Municipal Boards, Improvement Trusts etc., and employers should, in close consultation and co-operation, take immediate steps for the provision of suitable quarters sufficient for the number employed in that area.

Welfare Work and Trade Unionism.

This conference appeals to the employers of labour as well as to the advocates of trade unionism to recognize the necessity and the desirability of welfare work, and places on record its belief that the welfare work movement does not wish to interfere with the legitimate growth of labour movement, taking as it does its stand on principles of humanity and industrial [redacted] irrespective of differences between capital and labour.

Temperance.

This conference is of opinion that all welfare work will continue to be hampered till the complete removal of the drink evil is secured by the immediate closing of all liquor shops in industrial areas.

All India Industrial Welfare Work Organization.

(*a*) That an organization called The All India Industrial Welfare Work Organization be established, and a provisional committee consisting of the following persons be appointed to frame Constitution and Rules thereof, and to take the necessary steps to carry out its objects and to report to the next conference committee :—

(1) Mr. W. H. Wiser (Cawnpore), or Mr. R. H. Robinson (Cawnpore.)
(2) Mr. John L. Mott (Nagpore.)
(3) Mr. L. A. Brokenshire (Jamshedpore.)
(4) Miss G. A. Pearce (Madras.)
(5) Mr. K. P. Lele (Solapur.)
(6) Mr. H. C. Reed (Mining Federation, Calcutta.)
(7) Dr. A. N. Tankaria (Ahmedabad.)
(8) Mr. N. M. Joshi (Bombay.)
(9) Mr. S. B. Kulkarni (Bombay.)
(10) Mr. P. G. Kanekar (Bombay.)

The last two gentlemen should act as Provisional Joint Secretaries.

(*b*) That the above-mentioned committee be authorised to make the necessary arrangements for holding the next conference at such time and place as may be deemed suitable.

(*c*) That also an appeal be made to all industrial concerns to extend their financial and other support to this organization.

Indian Railway Advisory Council

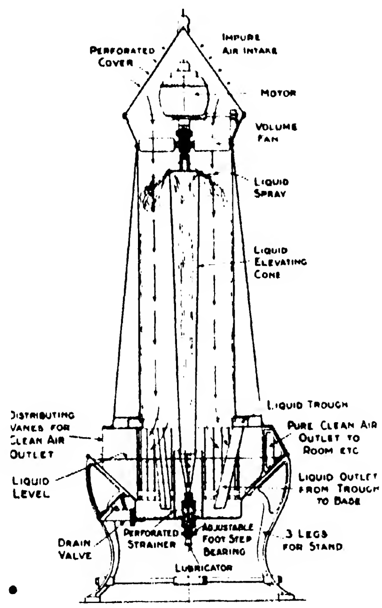
CONSIDERABLE dissatisfaction has been expressed at the action of the Government of India in appointing the Legislative Committee as the Central Advisory Council for Indian Railways. The action is, it is complained, diametrically opposed to the recommendations of the Acworth Committee, which intended that the Advisory Councils should be thoroughly representative of the principal chambers and associations representing trade and industry, and the local Legislatures, and, more especially, that many of the members should be nominated by the various chambers. It is certainly creating a political body in place of one representative of trade and industry and we cannot appreciate any point of advantage to be gained from such a course. If there are to be Railway Advisory Councils—and they have operated with signal success in other countries—there must be adequate representation of all interests concerned.

A New Air Purifier and Humidifier

The apparatus described in this article is the invention of the makers, Messrs. Smethurst & Sons, of Manchester. It is portable and self contained, and by making use of a fine water spray, the air in a room is continuously freed from impurities, and may be either humidified or de-humidified.

PURE air will consist of a mixture of 20.91 parts of Oxygen and 79.09 parts of Nitrogen by volume of 23.15 parts of Oxygen and 76.85 parts of Nitrogen by weight, with a small quantity (3 to 4 parts in 10,000), of carbonic acid, varying quantities of Aqueous vapour (water) traces of Ammonia, Nitrous Acid, etc., along with varying quantities of solid particles, dust, etc. Of these components Nitrogen does not combine readily with other substances and for that reason will remain unchanged and uncontaminated by the respiration of animals. The Oxygen will combine with carbon during the process of combustion when inhaled by animals, and will result in an accumulation of carbon di-oxide (carbonic acid), which is a gaseous compound. Inhaled in quantities above a certain amount carbon di-oxide is poisonous, while in smaller quantities it produces varying effects on the human system, resulting in headaches and weariness. The introduction of fresh air into a building, has, therefore, the effect of improving the condition of the atmosphere by the removal, or a reduction of the volume of carbonic acid the vitiated air may contain. Carbonic acid is readily soluble in water and is removed from the air, by nature, in various ways, among these being absorption of the gas by water and plants, and in this way the quantity of the gas is naturally kept down to three or four parts in 10,000, although air is considered pure, so far as this substance is concerned, when there are present not more than seven parts in 10,000.

Ventilating may be expressed as causing the air to pass through any place for the purpose of expelling impure air and dissipating anything noxious. This process is usually performed, and the invigorating effect on the atmosphere is obtained by the induction of a less vitiated air, and the ejection of the more vitiated air,



STANDARD MODEL SIZE 3.
SMETHURST'S PATENT "VIGORATAIR" MACHINE FOR EXTRACTING DUST FROM THE ATMOSHERE COOLING CLEANING & DISINFECTING AIR.

Fig. 1

the latter to be purified by natural means. The methods of purifying the atmosphere by nature rely on two mechanical processes, the absorption of the foreign matter by water and the circulating of the air by winds; the purification performed by vegetable life is a chemical operation. Falling water in the form of rain is perhaps nature's most perfect one of clearing the atmosphere of gaseous and solid impurities, by this means the air is thoroughly washed and the whole of the foreign matter it may be carrying is eliminated. In ordinary ventilating systems there are two possible sources of failure, or at least has imperfect or injurious effects—first the passage of air over a large area is a necessity, the speed of the current may vary from different causes and an unpleasant draught will be the result; second the volume of air induced or expelled must be calculated on the amount of vitiated air and the rate of its contamination, which is a variable quantity. Further, the source from which the supposed pure air induced is received may itself be contaminated and hence no purification can take place. Perfected systems of Humidifying embody the principle of washing the air as it enters the building, but no method of washing the air while it is in the building has been adopted, so far, and the vitiated air must again be extracted from the building, creating another current of air.

Messrs. Herbert Smethurst & Sons, Ltd., of Manchester and Hollinwood, have patented and successfully placed on the market, an apparatus that performs the natural system of purifying the atmosphere in the room. The operation may perhaps appear to be reversed, the effect of falling water is obtained by an upward current of water spray, while the effect of the wind is obtained by collecting the air over a given area and slowly impinging the vitiated air on to the upward current of water, the pure air escaping at the base of the apparatus. These movements create a natural current of air from the lower strata to the higher, the higher area without draught and thus "remove the foul air to replace it by pure clean air," which is said to be the "absolute essential in ventilating." The apparatus is self-contained, each one works individually, or may be operated collectively, and may be placed in various positions of height and distance to suit the circumstances of the case. It consists of an outer case (as illustrated in Fig. 1.), made in various sizes. The top cover of conical formation is made of perforated metal and through this the vitiated air is induced by means of an interior fan, and is delivered purified through the vanes at the base of the apparatus. The pan forming the base of the apparatus is

filled with water. The whole of this portion of the apparatus is stationary and is of pleasing design and substantial construction.

The circulation of the air and the water within this casing is performed through a hollow cone-shaped tube (inverted) revolving in an upper and a lower bearing. Above the upper bearing the tube is provided with a shaft on which is fixed a fan to create the air induction, and a small motor driving the fan and cone tube together. At the base of the cone tube the tube rapidly tapers to a point which is sealed by a short spindle suitable for bottom bearing. The rapid revolutions of this member creates two effects: the pointed end of the tube terminates at the lower level of the water in the pan and the water is elevated up the interior of the tube through a small hole in the extreme base of the tube by centrifugal force, which carries the water upwards to the wide portion of the tube in the form of a film, which is converted into a spray on leaving the top, when it falls back by gravity to the pan reservoir. The fan fixed on the upper part of the shaft induces the vitiated air through the perforated cover and forces it down against and through the water spray, and it is eventually ejected through the vanes at the base purified and cleansed. The natural effect therefore, is to dissipate the carbon di-oxide, the ammonia, the nitrous oxide and other noxious gasses through the absorption of the water; the solid particles are washed out of the air and are deposited in the water pan to be periodically removed by the drain. The object of the vanes, at the base of the apparatus, is to prevent the water, under the influence of the rapidly revolving inner cone tube, being sprayed on the surrounding outside, and this it does effectually. Each of the component parts can be readily removed for inspection or cleaning, the top perforated cone from the body, the body, containing the circulating cone, from the interior, leaving the base and water reservoir, and from this latter the strainer or sieve for solid particles. The capacity of the cleaning powers varies with the size of the machine or the diameter of the fan, and incidentally to the speed at which the latter is driven; this latter also having a direct bearing on the amount of water passing up the cone tube. The smallest apparatus will purify the atmosphere at the rate of 10,000 cubic ft. per hour, the larger size will effectively deal with 250,000 cubic ft. per hour, and as previously stated, larger machines can be constructed to deal with a greater volume. The working of the apparatus is scientifically correct and is simple of manipulation; these advantages render it particularly adaptable to large or small rooms. The purified air leaving the base of the apparatus is also humidified and is influenced by the temperature of the incoming air and water employed. Other uses of the purifying water may be found by mixing the water in the pan with disinfectant, deodorizer, scented, or a chemical solution, to overcome any contamination to which the atmosphere may be specially liable. No special fittings are required for the installation of the "Vigoratair," the smaller sizes will run off the ordinary electric lighting current. The apparatus will stand on the floor, on a table or an ornamental stand, and as previously remarked, may be moved from one position to another to obtain the best results. More elaborate fittings can be supplied to suit special requirements, for example, an electric heater or a steam coil may be inserted in the top perforated cover, to vary the temperature of the air, or the pan reservoir may be connected with a steam coil to evaporate the water for hastening humidification, or through the same circuit as the steam a refrigent may be passed to cool down the water and the air as it passes through the spray which will also reduce the water vapour from the air as required for cooling and dehumidifying. Also when a number of machines are operating in large areas the "Vigoratairs" may be connected up to a supply tank and ball tap to maintain a regular supply of water to compensate for evaporation.

Industrial Application

The application of the "Vigoratair" may be generally adopted in weaving sheds, ring and mule spinning rooms, cardrooms, clothing factories, hosiery mills, flax and jute mills, worsted factories, etc., etc., and also in workrooms of every description and a hundred and one other trades.

De-Humidification.—The "Vigoratair" may, with the addition of a refrigerating coil, be adapted for de-humidification of the air, especially in India, China, Japan, and South America, where the condition of excessive moisture is present in the atmosphere and which retards the full mill out-put during a greater part of the year.

Commercially.—The application of the "Vigoratair" may be generally applied in offices, banks, warehouses, store-rooms, food-stores, etc.

Other General Applications.—Cinemas and schools would find the application of the "Vigoratair" very advantageous. In the former draughts are far too frequent for comfort, as a rule, thereby resulting in many vacant seats, whilst with the aid of this machine there would be no inconvenience whatever. In schools it could be used at any time desired, particularly in the late hours, when weariness, lassitude, and want of attention are noticeable in both teacher and scholar.

Cafés, hotels, smokerooms, steamboat lounges, etc., all of which are often found to be unhealthy and unbearably stuffy, could easily be rendered clear and comfortable by the application of the "Vigoratair."

Hospitals would be able to dispense with the use of jars of standing water and periodic spraying. The purification and disinfecting would be performed continuously day and night—with the "Vigoratair" which, whilst working, is practically noiseless.

Motor Traffic and Road Conditions

A VERY important question in the consideration of motor transport development is that of road conditions. We have been brought forcibly up against this trusim by painful experiences in certain Continental countries where, in the course of many hundreds of miles motoring, we suffered from the defective road surfaces. In Great Britain, very careful attention is being paid to this matter, many new arterial roads constructed of reinforced concrete, and specially built to withstand heavy motor traffic, having been developed within recent years. India has much to consider in this connection, and we could wish that the question of transport had been treated comprehensively, as the Acworth Committee considered the railway problem. That may come, however, in good time.

TRANSPORT

Conducted by "M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH THE MANAGEMENT AND CONTROL OF RAILWAYS

Concrete Roads (II.)

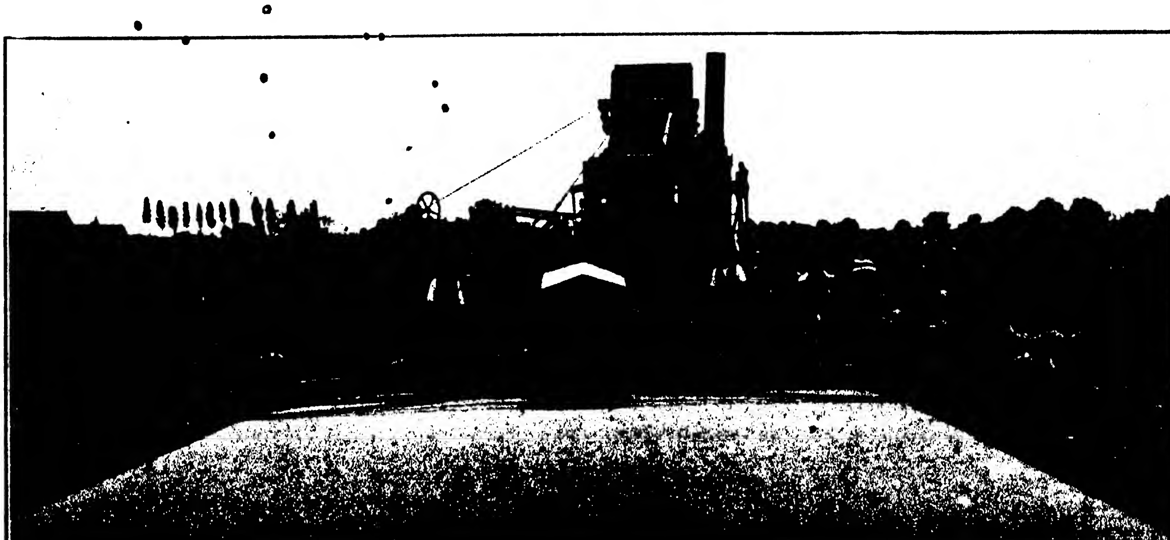
(*Concluded from page 617, Vol. I.*)

IN this article we conclude Mr. J. H. Walker's paper on concrete road construction, which includes a detailed description of the methods evolved by the author's firm, known as the Walker-Weston system. For illustrations of the reinforcements used we would refer readers to our June issue.

Laying in Alternate Bays

It is interesting here to note that Mr. Boulnois in 1917 published a draft specification for the making of concrete roads in which he recommended the concrete to be laid in alternate bays. It is necessary, however, to point out that such bays with ordinary vertical joints are, without a system of interlocking one with the other, open to a great objection of tending, under heavy loads concentrated on the edges, to sink locally like a raft at sea similarly loaded with the result that the wheels pound and wear away the raised arris of the adjacent slab. Thanks to the energy and enterprise of the Walker-Weston Company this difficulty has been provided for by locking the slabs together.

Concrete expands through heat ⅜ in. per 100 ft. for every 50 deg. F. rise of temperature. In a long stretch of concrete road subject to exceptionally high temperatures on a blazing hot summer's day, concrete even with expansion joints has been known to fail by buckling upwards, partly, perhaps, due to too little thickness and consequent lack of weight to keep it down, and also to bad workmanship at the day-work joints, each stunt-end has been left at night with a laitance-covered slope instead of a perfectly vertical face from the formation to wearing surface. In the latter case, failures have taken place through the slab at one side of a joint sliding upwards over the adjacent slab (see "Concrete and Constructional Engineering" for August, 1921). It is advisable, therefore, to have a sufficiently thick slab, and not to err in the other direction from a false economy point of view. The early American concrete roads were principally country roads, about 15 ft. wide, taking the place of unmetalled earth roads, and many were made 6 ins. thick and less with a view to getting maximum mileage for the money available. The Report of the U.S. Bureau of Public Roads, resulting from a study of the Californian State Highways System, where hundreds of miles of concrete roads have been laid since 1913, states as regards concrete roads :—



Mixer and Tamper making face of road — *The Walker-Weston Co. Ltd.*

"It cannot be said in 1920, in the light of the fact that the great usefulness of the Highway System is now proved, that the State would have realized its usefulness and provided funds in equal volume had not the system been extended as rapidly as it was, and at some sacrifice of either temporary or ultimate durability to increased mileage.

Increased Thickness in Concrete Roads

"The present American practice is towards giving increased thickness over those previously employed. Requirements from roads in Great Britain are more exacting than in American country roads fed by rutted grass tracks unsuited for heavy British road traffic, and where, in the United States, cracks in the roadway are looked upon by many engineers as inevitable and accepted as such. It is therefore not to be accepted as indisputable that English practice should follow blindly on American practice, either as regards thickness of slab, method of construction, or the complacent acceptance of irregular cracks in the road surface, which latter in Connecticut and other places have obviously been found to be far more difficult of maintenance than straight thin joints of predetermined spacing."

Now, having some of the physical facts relating to concrete with a few comments thereon, it will be of advantage if, with these in mind, we proceed to see how some of the present-day methods of Great Britain conform with them.

A Typical Case

A typical case is of a road 20 ft. wide, with a 6 ins. thickness of concrete reinforced with either double-layer pyramidal steel mattress with equal strength longitudinally and transversely, or with one of the various types of single-layer meshes having the main reinforcing bars running in one direction only, and laid either near the underside or near the surface, according to the preference of the engineer. In some cases the single layer meshes are duplicated and laid in position separately, one near the underside and one near the surface of the slab. The bottom 4 ins. of the slab is of suitable aggregate with perhaps a weaker mortar than the top 2 ins., the aggregate of which latter often consists of small-sized granite chippings. If the road is to be finished off with a wearing coat of tar and chippings, the surface is left somewhat rough.

The concrete is put down in continuous lengths around the reinforcement with expansion joints or not, as the case may be. If expansion joints are provided they are spaced according to individual preference, at distances varying from 50 to 500 ft. To prevent wear of the exposed concrete arrises at the expansion joints, steel protection plates are sometimes used, which have the disadvantage that the traffic transfers the wear from the joint to the concrete at the back of the plates. At the end of the day, the concrete is brought to a rough vertical face, and extra longitudinal reinforcement perhaps inserted. The reinforcement is left protruding ready to bond to the next day's concrete. It is often considered satisfactory, owing to the continuous reinforcement making it difficult to put up a workmanlike stunt end board right across the road, to make as good a job as possible with small pieces of wood stuck in the ground, and to keep the top 2 ins. a little way back from the end of the bottom layer. Sometimes, a very objectionable practice is adopted of putting down ahead of the main body of concrete small banks of concrete, in the top of which are embedded temporary wood screedings strips for levelling the surface. In other cases, the bottom concrete is put down continuously, and the top 2 ins. surfacing added after the lower layer has set hard. Here we have many instances of laitance planes between successive days, with the certainty of failure and increased maintenance due to sooner or later formation of irregular tracks, which are the bugbear of concrete road makers, and apt to be accepted as inevitable with a resignation worthy of a better cause. Again, it should always be borne in mind that where we put down new concrete against the previously laid and set concrete so that the former, at the point of contact is waney-edged, or wedge-shaped, there will be a source of weakness, and the concrete will eventually break away and cause big holes.

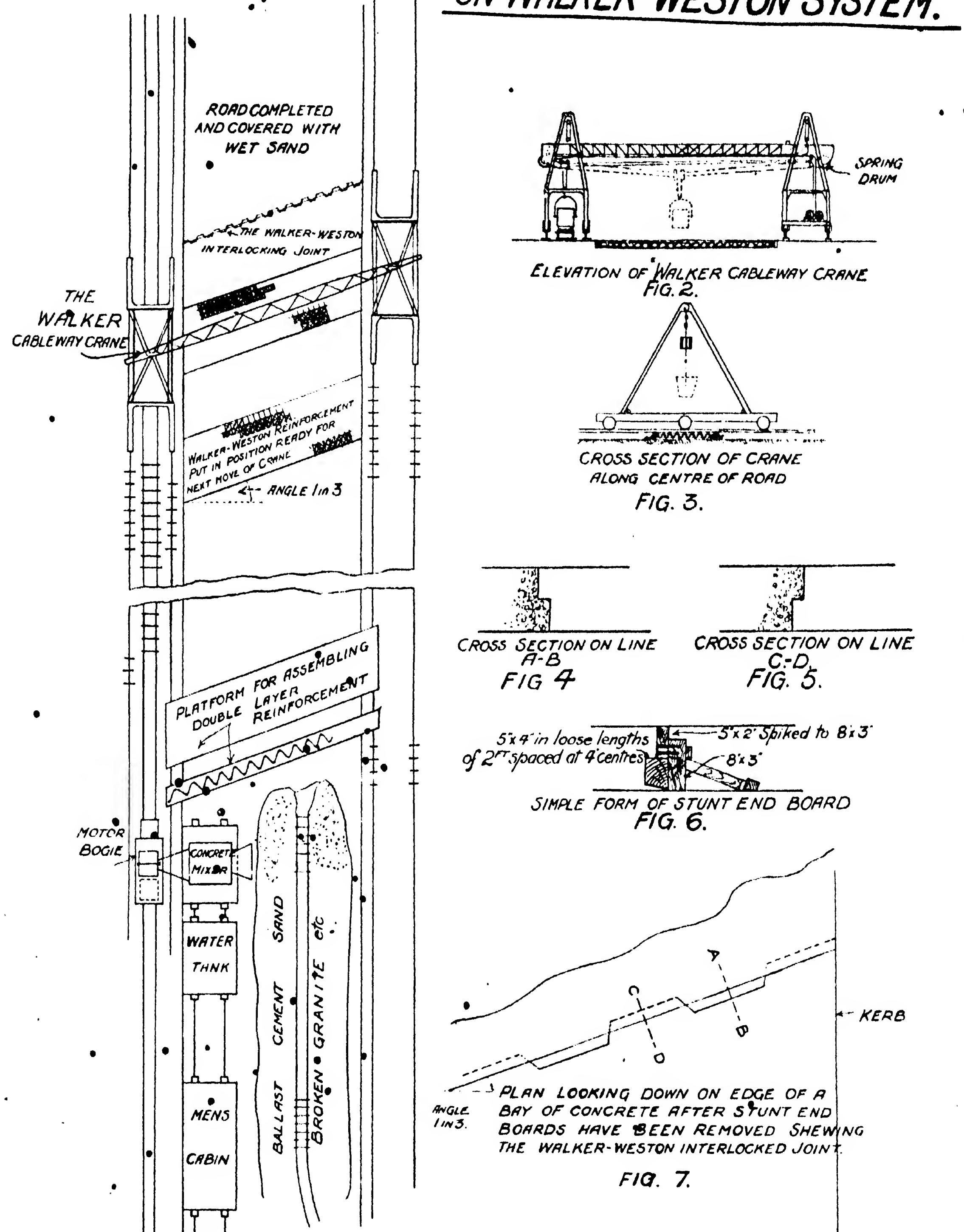
From what has already been said of the characteristics of concrete, the evils of some of the present-day methods should be obvious.

How Concrete Roads Should be Laid

It is, however, an easy matter to criticise adversely designs and methods of construction in a new industry such as the making of concrete roads. Far more instructive it is to state how concrete roads should be made in order to conform with the known facts of the physical characteristics of the materials employed. This we will now describe, and for our purpose take the case of an entirely new arterial road, built up in the open country, and required to take the fastest and heaviest type of present-day traffic. Where existing town roads have to be made in concrete, one half of the road at a time, the methods of construction have to be varied to suit altered circumstances, but the essential principles are easily adhered to.

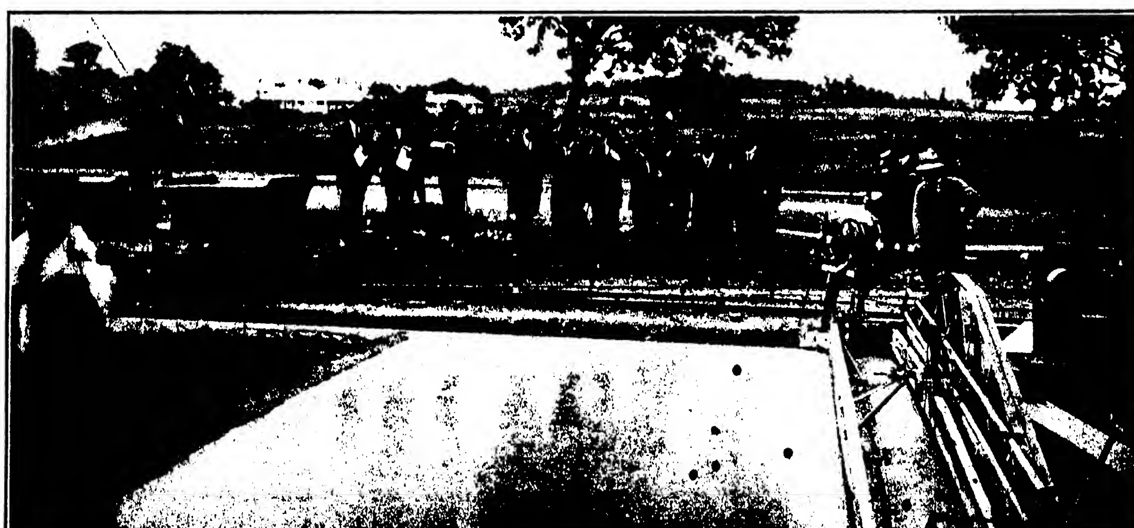
Fig. 1 shows a plan of a stretch of concrete road 30 ft. wide. The concrete is of a minimum thickness of 9 ins., 10 ins. or 11 ins., according to the nature of the formation, etc. The bottom layer of concrete is 6 to 1 ballast concrete, whilst the top layer, 2½ ins. thick, consists of a 1 to 1½-3 mix, the aggregate being of tough granite well broken into approximate cubes to pass through a 2½ ins. ring, and be retained on a 1½ ins. ring, all flakey granite to be rejected. The reinforcement to be of double-layer mesh connected together with diagonal tension members. The weight of the mesh to be 10 lbs. per square yard and upwards, according to requirements. The top layer of concrete is laid on the bottom layer before the latter has set. As soon as the top surface can be walked upon without injury, it must be well washed and broomed to remove the laitance, and so leave each granite stone clean and standing well out of the mortar. The concrete to be kept wet for 10 days after setting. Some time before traffic is put on the road, the surface to be well brushed clear of dust and grit, and to be covered with tar or bitumen and granite chippings. Great importance is placed upon efficient washing and brushing of the top surface to remove laitance. This latter, properly done, is cheaply and easily carried out, and ensures a lasting coating far superior and more efficient than that put on a good water-bound macadam road. This carpet is easily renewable every one, two or more years, according to amount of traffic, and in addition to taking the wear, serves also to pro-

— SCHEME FOR ARTERIAL ROADS —
ON WALKER-WESTON SYSTEM.



tect the concrete from varying alternations of wet and dry with its consequent bad effects. Some engineers specify the top coating of concrete to be of fine aggregate, and propose to take the wear of the traffic direct on the concrete. Others use fine aggregate in the surface layer and also put on a tar carpet, which latter soon wears off in patches due to the laitance on the concrete surface. Experience goes to prove that large-sized aggregate for the top surface is preferable to that of less than ⅜in. and upwards to ⅝in., which latter crush like nuts under the action of iron tyres of heavy axle-loaded steam wagons. Some engineers prefer to let the unprotected concrete take the wear of the traffic for some indefinite period, and afterwards, pressions in the concrete—it is not glaring to the eyes, like an uncoated concrete road, and it is more pleasant for the traffic to pass over. Concrete roads, although a new departure in engineering, are entitled to just as much fair play as steel bridges and exposed timber structures, which are painted and re-painted as and when necessary.

The concrete to be laid in alternate bays 10 to 12 ft. wide, with the reinforcement not continuous from bay to bay, and the bays are preferable placed at an angle of 1 in 3 to 1 in 1 instead of square across the road. The intervening bays to be filled in after the alternating bays have set hard and have taken up part of their setting contraction. This results in the inevitable 1 in. contraction in road is easily understood when it is recognised that as each slab is practically a raft on a more or less movable foundation, it is desirable, for more reasons than one, not to have both the wheels of a heavy axle load resting on the edge of a slab at one time, but rather to have the weight spread on two slabs. The same reasoning accounts for the adoption of the simple form of concrete vertical forms with slip-in pieces (see Figs. 4 to 7) whereby each adjacent slab is interlocked vertically and sideways, one with the other, in such a mannner that the weight of a rolling load passing over a joint is at all times supported by both slabs. If the alternate slab method of laying concrete be used with simple vertical joints, a heavy rolling load would tend



A meeting of Civil Engineers viewing operations

The Walker-Weston Co. Ltd.

when the surface is worn (as likely as not unevenly, and in grooves and pot holes) to apply a top dressing of tar and chippings. This doubtless follows from disappointing results in previous attempts to make a tar carpet adhere to a concrete surface covered with dried laitance scum. Here, again, is seen a reluctance to face facts as we know them, and to adopt methods accordingly. A bitumen or tar-dressed road gives a waterproof coating to the concrete, and prevents alternations therein of extreme wetness and dryness, with their accompanying detrimental effects. Properly applied it has a far longer life than on a macadam road—it is easier to renew it than to hack out and patch up holes and de- each stretch of road laid continuously in day-work lengths of 100 ft. being split up into straight joints about 1/15 in. wide instead of the large straggling cracks so detrimental to maintenance. The tar or bitumen coating afterwards applied has sufficient plasticity to span these thin joints. These latter act as expansion joints to provide for increases in temperature even in cases when the road is laid, as is preferable in the colder months of the year, when the resulting crack in the joint will be less than in roads laid in hot weather.

Reason for Interlocking Joints

The reason for the inclination of the slab out of the square with the to press down the edge of a slab, and passing across a joint, knock off the arris of the adjoining unloaded and undepressed slab. This latter action would soon result in innumerable holes in the roadway at the joints in the slabs.

It will be readily seen that with the alternate bay method of laying concrete areas, a method long recognised as appertaining to all high-class engineering construction, such as, for instance, Admiralty work, it is necessary to carefully plan out the means of carrying out the work at site in order to obtain maximum efficiency and economy in the road itself, together with a minimum of time required to execute the work.

It will be said that the American

methods recently introduced in Great Britain have been very successful in the United States in executing some 13,000 miles of concrete road with great speed and economy. Such is certainly the case, but it is considered that the efficiency of the finished roads, if called upon to bear the equivalent of present-day British traffic, requires to be considerably improved upon. The American type of concrete mixer, with outstretched boom for depositing the concrete in position, standing as it does on the formation and travelling back along the centre of the road as it lays the concrete, is obviously unsuited for the alternate bay method of making concrete roads, and was designed as a labour-saving proposition in constructing roads in continuous lengths. Similarly, the tamping machine, travelling longitudinally along the road, is also unsuited. Fortunately, there are other means as efficient and economical, whereby the road may be constructed in alternate bays and, as might be expected when the problem is fairly faced and solved, such means give other additional advantages not previously thought of.

A suitable plant lay-out for a road 30, 40 or 50 ft. wide is shown in Figs. 1 to 7.

The first considerations are the forming of the road bed and the delivery of materials to site. These will vary according to circumstances. Perhaps the delivery of the ballast, broken granite, sand and cement to the concrete mixer may be by rail or by road vehicle. A suitable arrangement is to store the material beforehand at various depots along the road spaced at, say, suitable intervals of 400 to 600 ft. In Figs. 1, 2 and 3 the road shown is 30 ft. wide. The concrete material is brought to site on a narrow-gauge tramway and dumped in mounds on the formation at suitable temporary depots. The concrete mixer can be oil-driven, and of ½ cub. yd. capacity, with an elevating hopper.

Cableway Crane

The road is spanned by a small type "Walker" overhead strut cableway crane, with a travelling portal trestle on one side of the road, and on the other side of the road a trestle mounted on a travelling platform on which latter is the operator with two winch drums and oil engine for actuating the cableway. The rails on which the trestles run need only be of light section spiked to longitudinal planks so as to be easily taken up, transported and re-laid. A light lattice girder, with an attached cableway underneath, is supported by block and tackle from the tops of the two trestles. This girder is of light construction, needing only to be made sufficiently strong as a beam to carry its own weight, and can be lengthened for use on a 40 or 50 ft. wide road by inserting the necessary extra length at central bolted field joints. As the girder is flexibly supported from the trestles, it is of little importance if the girder is level or inclined, or whether one trestle be moved, somewhat ahead or behind the other trestle.

This cheap and quick-working crane, which may be motor-driven or hand-traversed, can be converted into a tent by placing two scaffold poles across the road, supported by the under-framework of the two trestles. The suspended girder acts as a ridge over which to throw an awning, the two bottom edges of which are attached each to the foot of one of the scaffold poles. Such a tent can be internally lighted when the crane is in use on a dark winter's afternoon or otherwise.

As one of the chief difficulties in first tackling the problem of laying a concrete road 30 or 40 ft. wide in alternating bays was the lack of a machine capable of putting the concrete in place cheaply and expeditiously, it is pardonable to enter somewhat into the details of a crane so eminently suited for the work required, by its light weight and flexibility, particularly when we consider that the solutions of far more sensational load-handling problems by means of portable suspended overhead cableways originated in the successful endeavour to overcome this difficulty. For the benefit of those unacquainted with this simple type of crane, we would refer to the original and very successful timber-constructed crane of this type, forced concrete buildings in the docks primarily used, however, in laying concrete roads continuously before the interlocked joint for slabs laid alternately was invented, details of which are given in the previous publications issued by the Walker-Weston Company. We also give, in Fig. 2, details of the overhead strut cableway crane. This latter crane was used for placing scores of pre-moulded concrete beams, weighing 4 tons, anywhere as required by the Port of London Authority.

The buildings in this case were 440 ft. long × 120 ft. wide × 45 ft. high. For further particulars we refer our readers to the issue of "The Engineer" for December 24th, 1920. It needs little imagination to foresee further use for this type of crane, as, for instance, in excavating for roads where the crane, fitted with a single-rope grab, would span the entire width between boundary fences and excavate as necessary, dumping the material into railway wagons on lines between the two travelling supports of the loosely suspended overhead strut cableway.

To continue with our description of the method of constructing the road, the concrete is conveyed from the mixer on a small-rail motor-driven wagon, running on a narrow-gauge track. This car has a platform large enough for the two concrete tipping skips. The car takes a full skip from the mixer and runs with it under the portal trestles and stop under the cableway. The empty skip from the cableway is deposited on the car and the full one removed. The car then runs back to the mixer to get the empty skip refilled. The reinforcement proposed is of the double-layer pyramidal reinforcement owned by the Walker-Weston Company, which is bent and assembled in full-bay sections on the lightly-constructed movable assembling platfrom shown. The steel used is as sent direct from the rolling mills, all necessary bending done at site with local labour.

A careful study of the lay-out and a rough calculation of time and men required to do the work will suffice to give an idea of the speed, efficiency and economy with which the work can be carried out in either summer or winter. The motive power has been assumed above as of the internal combustion type, but a dynamo driven by an oil engine, both mounted on a bogie and supplying current to an overhead wire from which each machine and the lighting installation takes its current, is well worthy of great consideration, as also are other sources of power perhaps specially suited to the requirements of a particular locality.

It will be readily seen that all the plant is easily movable with the assistance of the small power-driven small-gauge motor bogie, and little delay results when it is necessary to move along the road to another depot.

It is unnecessary here to enter into further details of shape and con-

struction of formation, drainage, camber, the laying of the concrete in two layers, and the washing of the top surface to give a binding to the finished coat of tar and granite chippings. It is advisable however, to call particular attention to Figs. 4, 5, 6, and 7, which clearly indicate how the slabs are interlocked one with the other both upwards and downwards as well as transversely with the road, whilst giving freedom to the slabs to expand and contract lengthwise with the centre of the road. This method has been put into practice by the Walker-Weston Company Limited. Its use remedies the only defect in the otherwise excellent practice of laying concrete in alternate bays and makes such practice a perfectly sound and scientific proposition for concrete roads carrying heavy motor traffic. The drawings for the sake of simplicity show the forms as constructed in timber but for repeated use they are best constructed of steel.

The Need for an All-India Gauge Policy

By FREDERICK GEORGE ROYAL-DAWSON, M.INST.C.E.

Mr. Royal-Dawson recently dealt very fully with this important subject in a paper read before the Indian Section of the Royal Society of Arts, the first portion of which we reproduce here.

TEN years ago a paper on "Indian Railways" was read before this Society by the late Mr. Neville Priestley, a traffic officer who was at one time Secretary to the Indian Railway Board, and who subsequently became associated with the South Indian Railway, first as General Manager in India and finally as managing Director in London. Mr. Priestley's paper was taken up mainly with the financial side of the subject, the gauge question being only incidentally touched on as influenced by financial considerations in the past. Mr. Priestley's object was to show that an extensive programme of railway construction was needed, especially in the form of light feeder lines, to open out and develop the country, but that Government methods were not conducive to the encouragement of private enterprise in this direction. In particular, he sought to show that the high capital cost of some railways had been due to the Government's insistence on too high a standard of construction, and this gave rise to a question being asked in Parliament. But on this point he laboured under a misapprehension, for in the first place, not being an engineer, he perhaps did not realise that the first cost of a railway was influenced more by the nature of the country passed through than by any arbitrary standard of equipment or strength, and in the second place, his assumption as to the insistence of unnecessarily high standards was not in accordance with the declared policy of the Government, for although certain standards had been laid down for important lines, the Government had specially emphasised that such standards could be relaxed in cases where they were considered needlessly onerous. I may add that this attitude of "Gharib Parwar" or "Protector of the Poor" on the part of the Government in relation to light railways still holds good, only such standards of construction being insisted on as are dictated by common sense.

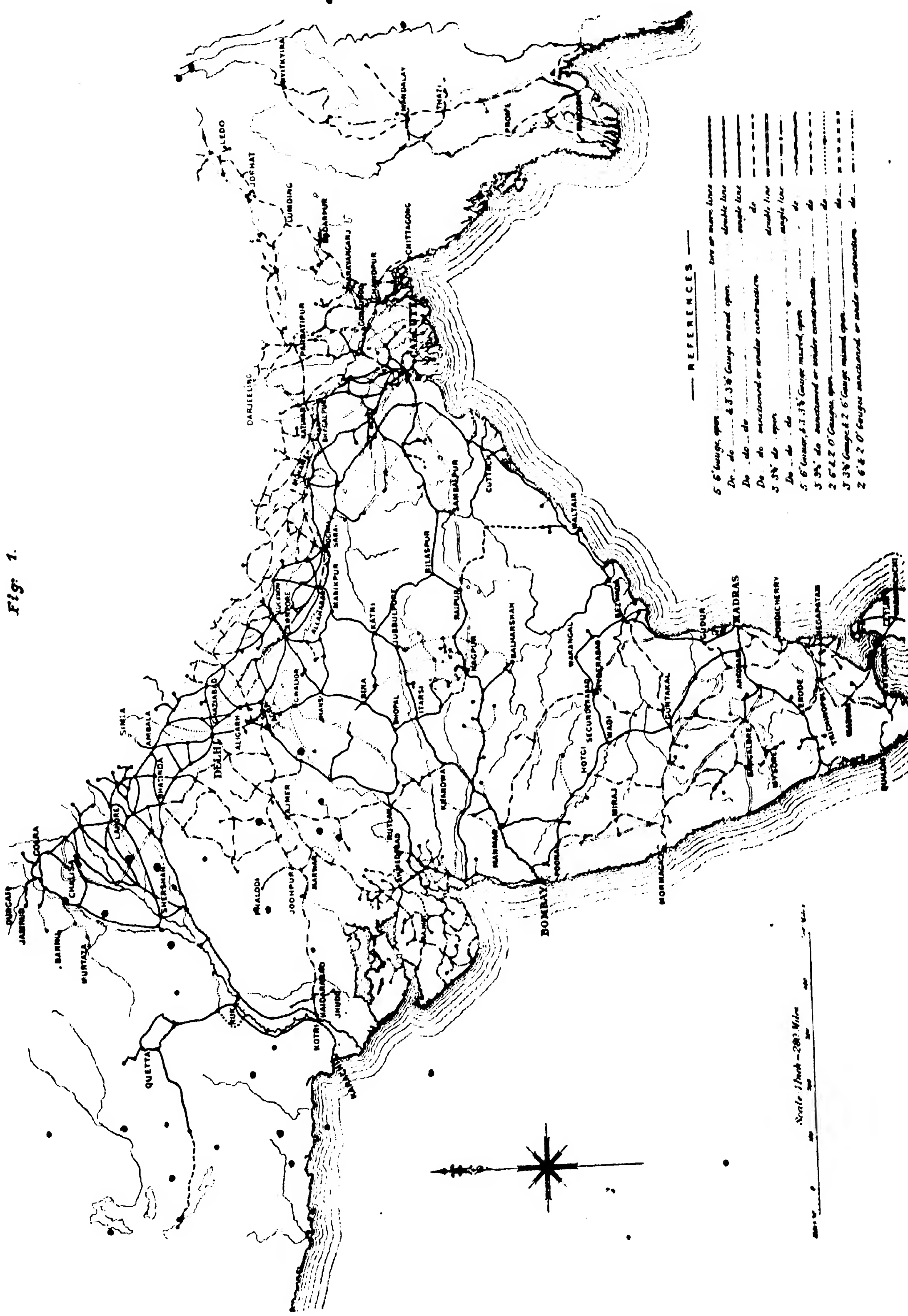
Government Method

The methods of Government in dealing with railways have, however, been exposed to criticism in other directions. For this reason a Commission was appointed the year before last, under the chairmanship of Sir William Acworth, to consider the whole question of the administration of Indian Railways, including the general question of railway finance, also the knotty question of State versus company management, and the adequacy or otherwise of the system of administration and control by the Railway Board as at present constituted. Their report was published last year. Although the gauge question was not specifically included within the scope of their investigations they recommended (with one dissentient) that this question should be referred to a Committee of experts. This report is now under consideration.

In the meantime the Institution of Civil Engineers kindly gave me an opportunity, for which I am much indebted to them, to present a paper on the subject of the Gauge Problem for discussion in that Institution last November. This paper was somewhat technical in detail, but the discussion which it elicited was most valuable in that it indicated that the majority of those who expressed their views and who were competent to form a disinterested opinion on the question, agreed generally with my conclusions. By means of the discussion, also, I was placed in possession of the strongest potential arguments that could be brought forward by opposing interests against my proposals and have thus had an opportunity to give these arguments full consideration when preparing the present paper. I am therefore in a position to assure this audience that the views which I am about to express, although not official, are backed by a large body of disinterested opinion, that such adverse criticism as they have already received has been considered and dealt with in this paper, also that they are not novel in character, but merely that they have been brought up to date. I may also add that they do not conflict with any Government policy for the simple reason that the Government has no definite policy on the question at present.

INDIAN RAILWAY GAUGES.

Fig. 1.



It is necessary to begin the subject with a brief history of Indian Railways from the gauge point of view. Railway construction began in India about 70 years ago, that is in 1851, at a time when there were two legalised gauges on English railways, namely 7′ as used on the Great Western and the Railways which it absorbed, and the 4′ 8½″ as used on all other lines. A passing reference should be made to the "Battle of the Gauges" which had been fought in England a few years before, when other gauges had also been in use. The net result of that battle was the public recognition of the fact that the inherent merits of any particular gauge were as nothing compared with the nuisance of a break of gauge, which prevented the rolling stock of one gauge being used on another. The first step towards the diminution of this nuisance was the legalising of the above-mentioned two gauges only, to the exclusion of all others. The second step came some years later when the Great Western, the sole representative of the 7′ gauge, decided to abolish it in favour of the more general 4′ 8½″ in the interests of unification, thereby serving its own as well as the public convenience. For some years before the final abolition of the 7′ gauge in 1892 the Great Western had adopted a mixed gauge on a portion of its main line, the track consisting of three rails, one rail being common to the two gauges. This was only the beginning of the end, for it was felt that the supposed advantages of a mixed gauge were not worth the complications involved in its maintenance as a permanent feature in dealing with a busy traffic. The use of the third rail, however, showed that such a device could serve a useful purpose during the transition stage of a contemplated conversion.

America also had its "Battle of gauges," all lines being ultimately unified to the 4′ 8½″ or 4′ 9″ gauge in the interests of free interchange of traffic. This gauge has also become the main European Continental gauge.

With the above object lessons before them, the Government of India decided in 1851 that whatever gauge should be adopted in India, that gauge should be enforced for all railways, to avoid the evils of break of gauge. The actual gauge chosen as the legal standard was 5′ 6″, being intermediate between the two English gauges of that period. Incidentally it may be mentioned that this gauge was chosen to give, not greater capacity, but greater stability than the 4′ 8½″ gauge, as with carriage bodies of the same width there would be less lateral overhang in the rolling stock of the 5′ 6″ gauge.

Reason of High Cost

Within the next fifteen or twenty years, about 5,000 miles of line, comprising the principal trunk routes leading from trade centres to ports, had been laid to this gauge by various companies with sterling capital on a 5 per cent. guarantee.

Unfortunately, these original lines were very costly in consturction, not so much because the standard was unnecessarily high, but rather because the nature of the work was new, while the country was also difficult, involving the bridging of wide rivers and in some cases the traversing of steep mountainous tracts. Added to this initial handicap, the fall in the exchange value of the rupee resulted in these lines being a financial burden to the State. So that in 1869, when further railway extensions were desired for the development of the country, it was thought necessary to introduce a narrower gauge, namely the 3′ 3⅜″ or metre gauge, to be constructed by State agency in order to cheapen the first cost of construction. Thus for the first time were financial considerations allowed to interfere with the principle of uniformity, hitherto held to be of paramount importance.

An extensive programme was then carried out on the metre gauge. It is, however, due to the Government of that period to say that it was never intended that the metre should ever be anything but a supplementary gauge confined to particular areas. Mr. Thornton, in defending the Government policy at a discussion in the Institution of Civil Engineers, in 1873, said, "In India there was no idea of letting the two gauges come into competition. There were not to be any standard gauge lines and metre gauge lines running from the same point in the same direction. Goods brought by railway to any station at which the break of gauge occurred, and intended to go on by railway, would have no choice but Hobson's. They must either proceed by the metre gauge or by the standard gauge, as the case might be, or they could not go on by railway at all, for there would be but one gauge to go on by." It is thus evident that whether the introduction of the metre gauge was right or wrong in principle, it was fully intended to restrict the activities of that gauge to definite regions. To perceive to what extent that idea has been departed from, it is only necessary to glance at a present-day railway map of India (vide Fig. 1.)

While the broad gauge still predominates the metre gauge crosses it at many points. The original metre gauge State lines were the Indus Valley and Punjab Northern (since converted to 5′ 6″ and merged in the North Western Railway), the Rajputana-Malwa, still on the metre gauge, but worked by the Bombay-Baroda broad gauge administration, the Tirhoot (now worked by the Bengal and North Western metre gauge railway, which came later), and the Northern Bengal now forming the metre gauge section of the Eastern Bengal Railway.

Later on came the Southern Mahratta Company's Railway on a guarantee, and the Bengal and North-Western without guarantee. The former is now incorporated in and worked by the nucleus of the old broad gauge Madras Railway, while the Bengal and North-Western, though financially independent, has, from an early period, benefited from the fact that the lucrative Tirhoot Railway has been leased to it. In the meantime the Assam-Bengal and Burma Railways on the metre gauge came into being.

In the South of India the portion of the South Indian Railway between Erode and Negapatam was originally broad gauge, but is now metre.

Up to this stage the metre gauge areas were fairly well defined, but as the trend of affairs seemed uncertain, the Government in 1889 invited a Committee of railway officers to enquire into the gauge question. This Committee recommended definite recognition of the 5′ 6″ gauge as the standard for India, and the rigid prohibition of any extension of the metre gauge, except in areas where it was already established. They further recommended that all feeder lines should be constructed on the same gauge as the parent line, but that anything of the nature of link connecting with broad gauge railways should be either constructed on the broad gauge, or so constructed as to be easily converted to it.

But these recommendations were not acted upon, for in the nineties the idea was started that all metre gauge railways should be connected with one another by metre gauge

links. As a result of this heresy, the Cawnpore-Barhwal link, 80 miles long, was constructed by State agency across the broad gauge territory of the Oudh and Rohilkund Railway and actually alongside the broad gauge track of that railway between Cawnpore and Barhwal, to connect the Bengal and North-Western with the Rajputana-Malwa and Guzerat metre gauge systems, while with the idea of an ultimate north-and-south metre gauge connection, the Hyderabad-Godaveri line, 391 miles long, was constructed over hitherto unoccupied territory, on the metre gauge, although connecting only with broad gauge railways at its two extremeties.

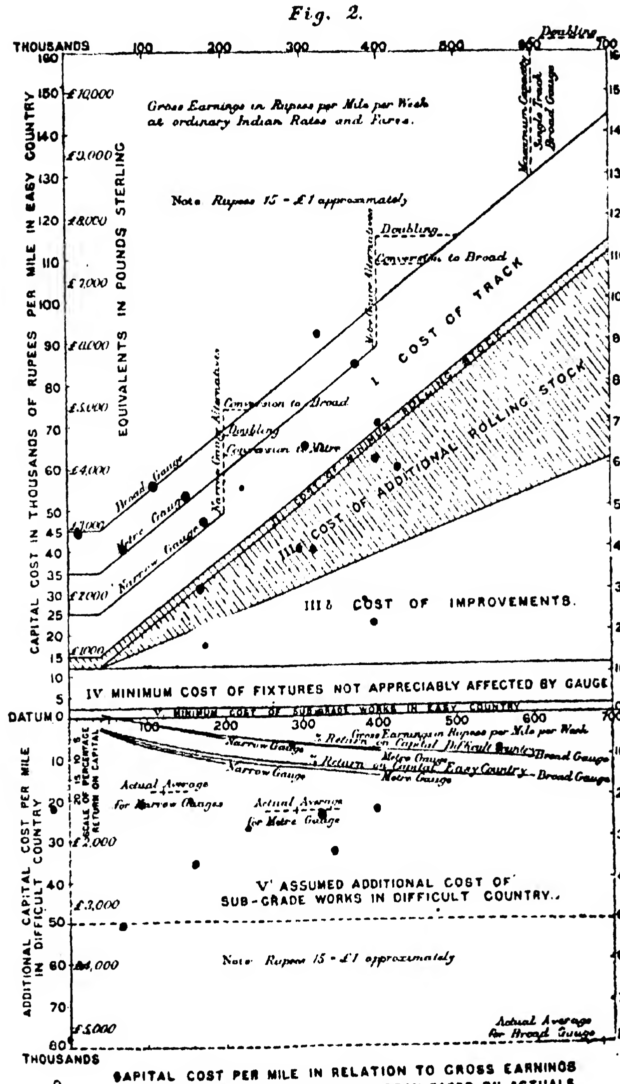
Thus the recommendations of 1889 have been scattered to the winds, and there is now considerable interlacing of the gauges. Although the Guzarat and Jodhpore-Bikaner railways connecting with the Rajputana-Malwa system appear to be at present in purely metre gauge territory, the Karachi-Agra broad gauge project, which is likely to materialise in the not very remote future, involves the conversion of the greater part of the Jodhpore-Bikaner main line to broad gauge, besides the crossing, if not the conversion, of a portion of the Rajputana-Malwa. Similarly the north and south backbone line of the metre gauge section of the Eastern Bengal Railway is in process of being converted to broad gauge. These contemplated conversions serve as illustrations of a generally accepted, though not officially recognised, principle that arterial routes should preferably be on the broad gauge, and that, as a corollary, if a metre or other narrow gauge line occupies an alignment approximating that required for a contemplated arterial route, it is, in the absence of specific legislation to the contrary, liable to be converted to broad gauge. As we have seen, some of the original metre gauge lines, such as the Indus Valley, being arterial in character, were subsequently converted to broad gauge.

A notable exception is the Rajputana-Malwa, which, before the construction of the Nagda-Muttra, was aligned on an arterial route between Delhi and Bombay, breaking gauge at Ahmedabad. It was at one time contemplated that this line would be ultimately converted, in anticipation of which it became the practice, when girders were due for renewal, to renew them up to broad guage standard. Then came the construction of the Nagda-Muttra broad gauge railway, on an alternative alignment, through much more difficult and less productive country. This line, it is true, takes a heavy through traffic, but there is no apparent reason why, if the Rajputana-Malwa had been converted to broad gauge, as originally contemplated, it could not have dealt with this through traffic as well as its own. Of course, it may be argued that the Nagda-Muttra has served to open up new country, but, taking a wide view, the anomaly remains that, as between the two alternative routes the more important and less difficult terrain of the Rajputana-Malwa is served by a metre gauge railway, while the less important and more difficult terrain of the Nagda-Muttra is served by the broad gauge. The acquired importance of the latter is derived mainly from its through traffic, which has been more or less diverted from the Rajputana-Malwa and the Great Indian Peninsula routes between Delhi and Bombay.

The true explanation of this retention of the Rajputana-Malwa as a metre gauge line is, perhaps, to be found in the Cawnpore-Barhwal metre gauge link, already referred to, traversing the broad gauge zone of the Oudh and Rohilkund Railway, and actually laid alongside a broad gauge track, to connect the Rajputana-Malwa and Bengal and North Western systems.

Thus, we see how one departure

Fig. 2.



CAPITAL COST PER MILE IN RELATION TO GROSS EARNINGS PER MILE PER WEEK. TYPICAL DIAGRAM BASED ON ACTUALS.

from principle has led to another. The first departure from principle was the introduction of the metre gauge, on the grounds of cheapness of first cost, to supplement the standard gauge, in spite of the break of gauge involved thereby. The next departure from principle was to connect two metre gauge systems with one another by a link traversing broad gauge territory, in order to increase the lead of purely metre gauge traffic, in full recognition of the fact that such a link represented redundant mileage, besides failing to obviate the necessity of transhipment points with the broad gauge in other directions.

It has been argued in defence of this particular example that the link was necessary in the public interests in order to develop the trade between the Sub-Himalayan region represented by the Bengal and North Western Railway on the one hand, and the Rajputana and Guzerat areas on the other. While fully recognising the force of the contention a counter argument would be that there is no *a priori* reason why, on public grounds, the Bengal and North Western Railway should be connected with the ports of Guzerat by an unbroken gauge, while it has to break gauge with the more important ports of Calcutta, Bombay and Karachi, involving transhipment at about a dozen different points. In short, weighing the arguments against one another, the suggestion arises that, on general grounds, links of this nature are more conducive to the interests of the linked railways than to public interests as a whole, in the sense that, while they may create new traffic, they also tend to influence the natural trend of traffic. It must also be obvious that, if this linking up policy were carried out indefinitely, it would mean redundant mileage and consequent waste of capital everywhere, while it would not save the general public from the evils of break of gauge until every station in India had been served by both gauges, which is a *reductio ad absurdum*. Short of that consummation, the aggregate tonnage of transhipment would increase concurrently with the co-extensive increase in the mileage of the two gauges.

The Different Gauges

To those who argue that the introduction of the metre gauge in the seventies was an economic necessity, in order to increase the railway mileage of India at a lower first cost than would have been possible by the use of the standard 5′ 6″ gauge, the reply is that an even greater mileage could have been secured for the same money by a yet narrower gauge, such as 2′ 6″. It is significant that the existence of the metre gauge has not prevented the subsequent genesis and growth of 2′ 6″ and 2′ 0″ gauges. To those who say that a narrower gauge would not have fulfilled the purpose for which the metre gauge was intended, the reply is that for thirty years after the metre gauge had been introduced, its average volume of traffic, measured by earnings in rupees per mile per week, had not attained the figures which several 2′ 6″ gauge lines can show at the present day. It should, however, be remarked that certain original metre gauge lines, such as the Indus Valley and Punjab Northern, were subsequently converted to broad gauge.

Assuming, however, that the metre gauge performed a useful function at a certain period in railway history, thus condoning the breach of the principle of uniformity for the time being, the fact remains that the metre gauge has grown to such an extent as to constitute at the present time a second main gauge. In other words, a duel gauge is now in full play. The present railway mileage according to gauges is, in round figures :—

Broad gauge	...	18,000 miles.
Metre gauge	...	15,000 ,,
Narrow gauges	...	3,500 ,,
Total ...	...	36,500 ,,

These figures represent route mileage only. For actual track mileage the figures for the broad gauge should be increased by about one-seventh to cover the double track portions on that gauge. With the exception of a small portion of the main line in Burma, and two short incidental "necks," seven and ten miles long respectively, in Upper India, the metre gauge is still practically all single track throughout India.

The outlay on the various gauges bears a close relation to their respective gross earnings, thereby indicating that the ultimate cost of a railway depends more on its volume of traffic than on its gauge. Thus, in 1883 the average cost per mile of a broad gauge line was 2.68 times that of the metre gauge, and the earnings 2.69 times as great. Again, in 1903, the average cost of the broad gauge was 2.49 times that of the metre, and the ratio of earnings also 2.49. Lastly, in 1920, the broad gauge cost per mile was 2.31 that of the metre gauge, and the ratio of earnings 2.35. It may be added that the average cost per mile of a narrow gauge line (2′ 6″ or 2′) in the same year was .57, or rather more than half that of the metre gauge, while the earnings per mile were .40, or rather less than half.

I leave the narrow gauges out of the discussion for the present, because in the first place their combined mileage is comparatively small, and in the second place they carry their own limitations in regard to capacity and speed, so that they can never attain the status of main lines.

The questions at issue are :—

(1) is a perpetuation of the dual standard desirable in the public interests ?

(2) If not, is alleviation of the evil financially practicable ?

I propose to answer the first question in the negative and the second in the affirmative.

(*To be continued.*)

In the 46th Annual Report of H.M. Inspectors of Explosives for the year 1921 it is stated that the number of accidents under the heading of "Use and Miscellaneous" was 205, causing 30 deaths and injuries to 219 persons. This compares with 48 deaths and 410 injured during 1920.

Railway Development in India

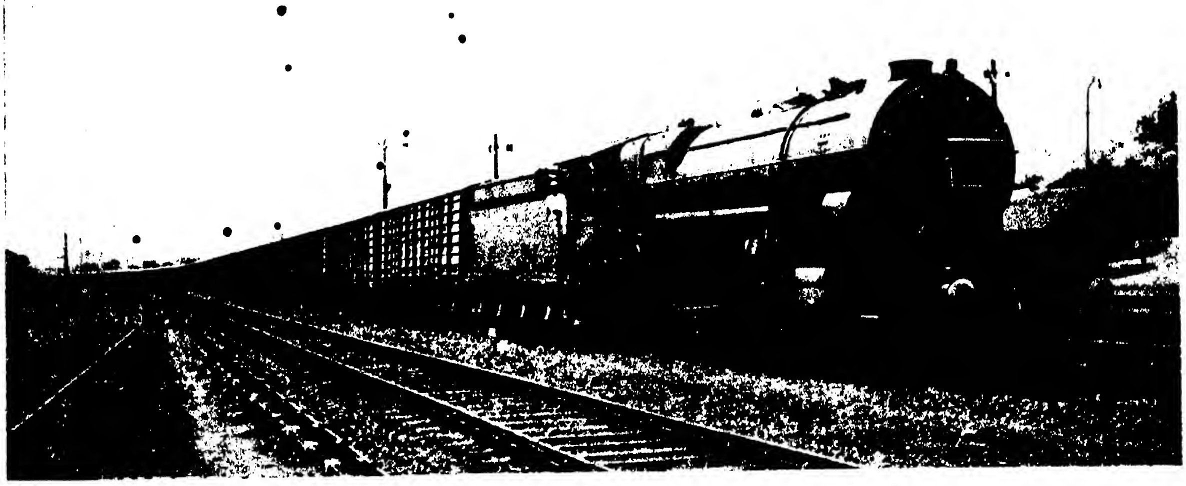
In the following article, one of our correspondents deals with the system of braking at present in use on the broad guage railways, and makes some important statements concerning the existing state of the vacuum system, and makes suggestions for the more efficient working of the braking system on the broad gauge tracks.

THE photograph we reproduce represents a goods train of a capacity the G.I.P. Railway Administration is anxious to consider regular practice on its lines. The locomotive hauling the train is one of a new type of 10-coupled goods engines recently put into service, and the train behind it consists of 37 bogie wagons, each of which can carry 40-50 tons of cotton or other merchandise. The train is fitted throughout with the automatic vacuum brake and has at the rear a single van of only 10 tons weight. The contention of the G.I.P. authorities is that the only safe conditions to run such a train as this is with the automatic continuous brake in operation throughout. If this is not working, then they must attach at the rear *three* 20-ton brake vans, with three independent brakesmen to operate them. The necessity for this brake power at the rear is due to the unreliability of the screw couplings which are practically strained to their limit when located at the front end of such heavy trains as this. It is needless to point out that the provision of these additional goods brakes at the rear means an increase in weight for the locomotive to haul, of 50 tons over and above the tare of the train equipped with continuous brakes.

The Indian Railway Conference Association has recommended to the Government of India that the continuous brakes shall be brought into full operation on all the broad gauge railways on the 1st April, 1924, and it will be under the conditions that will then obtain that the G.I.P. will be able to run goods trains similar to that of the photograph. Imporant proposals for the introduction of mechanical couplers to replace the screw couplings now used are receiving the attention of the Railway Board.

The present deplorable condition of the continuous brake equipment under the goods vehicles of the broad gauge railways certainly needs the serious and urgent attention of Government; the matter was vigorously discussed at the recent annual meeting of the Locomotive and Carriage and Wagon Superintendent's Committee. The suitability of the vacuum system for operating the brakes of long goods trains has frequently been commented on, and it would seem that a very critical period has now been reached in India. Apparently the Railway Board is not altogether satisfied that the best arrangement has been selected, for the question of the advisability of considering a change from "vacuum" to "air," was put to the Committee mentioned above.

Considering the enormous outlay of capital which has already been expended in equipping the bulk of the broad gauge stock with vacuum apparatus, the experts to whom the above question was addressed thought it desirable to withhold a reply until such time as they have had more experience with the vacuum brake in regular working. To secure general operation on all railways, requires the urgent orders of the Railway Board, and in the interests of economy alone that controlling authority should immediately insist upon the apparatus which has already been fitted to so many wagons of the broad gauge being brought into full operation; the piping of an additional 2,000 or



2,000 ton Train of covered bogie wagons fitted with the Automatic Vacuum Brake

Standard 20-ton Wagons coupled with Mechanical Couplers

3,000 wagons or so, to secure communication throughout the trains is a small matter when so many are already completely equipped.

There are approximately 6,000 locomotives, 14,000 carriages 140,000 goods wagons, and 3,500 brake vans in service on the broad gauge railways. For the purpose of this note, the locomotives and carriages can be omitted from the statement, although we can safely assume one half of the locomotives have been fitted with brake gear to enable them to operate the brakes of *goods trains*. Of the wagons, nearly 100,000 are equipped with complete vacuum brake apparatus, and as the equipment of each wagon represents something like 15 cwts. of material, there is practically a total of 75,000 tons of brake gear which has been purchased at a cost of some Rs. 450,00,000 being transported about the country rendering no useful service whatever. In addition to these, there are the 3,500 *weighted* brake vans, many of which can be relieved of their additional dead weight and utilized as vans for the transport of merchandise, if the continuous brakes were operated on all trains. A goods train similar to that of our photo carries approximately 50 tons of continuous brake work under the vehicles, and if this gear is not being operated, must have in addition three weighted brake vans at the rear, each taring 20 tons. The total weight of brake apparatus for the train will then be 110 tons, 50 tons of which represents the continuous brake apparatus under the wagons, being hauled about for no useful purpose. This is actually what is occurring daily on the Indian broad gauge railways, owing to the fact that all the Administrations *will not operate the continuous brakes throughout the trains.* If the continuous vacuum brake apparatus is put into action, operated from the locomotive, then the 3 20-ton brake vans can be dispensed with, and a 10-ton van substituted to carry the train staff as already noted, thus securing a saving of 50 *tons of dead weight* in the train.

Deterioration of Vacuum Brake Apparatus

It has been abundantly proved during the past 15 years, the period during which the vacuum brake apparatus has been in process of being fitted, that it deteriorates seriously and rapidly when out of work, hence the necessity to keep the vehicles equipped in regular working order, if the apparatus is to be maintained at reasonable expense.

We estimate from the figures published in the Administration Report of the Indian Railways, that if the continuous brakes were brought into full operation, it would enable the dead weight of all goods brake vans to be reduced to 10 *tons*, and this would probably result in a decrease in the aggregate of 20,000 tons of dead weight; further it would free at least 500 vehicles, which could be profitably utilized for the transport of freight. The present arrangement is most unsatisfactory and unbusinesslike. Thousands of rupees have been spent on apparatus which simply hangs under the wagons, rusts and becomes useless, whilst the actual requirements for the control of the trains are being met by additional loads of cast iron transported all over the country at costs varying from Rs. 8 to Rs. 10 per 1,000 miles.

British Railways Roads Bill Withdrawn

In view of the growing competition of road motor vehicles with the railways for selected classes of traffic, the North Western and Midland Group of Railways in Great Britain, recently applied to Parliament for powers to run road motor services on their own account. They already have large fleets of motor vehicles for collection and delivery purposes, but were proposing to compete on an even basis with the independent motor companies who sought to capture the highly-rated classes of traffic, which the railway companies can ill afford to lose.

The application proceeded favourably and eventually came before a committee charged with the duty of reporting to Parliament on the proposals, but after ten days' hearing the Bill was withdrawn after evidence had been given by a representative of the British Ministry of Transport, who objected to the railway companies charging dissimilar rates on traffic carried between any two specific points either by road or rail.

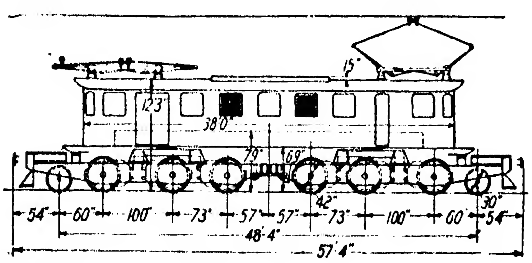
The objection made was on the basis that traffic carried by the railway companies on the road lessened "railway" revenue, and so enhanced the possibility of an increase of railway rates to enable the companies to obtain the standard revenue to which they are entitled under the Railways Act. While the views put forth were fallacious in that the conveyance by the railway companies by road of traffic, which otherwise would be transported by independent companies would directly benefit railway revenue, the railway companies had no alternative but to withdraw their Bill. The committee strongly criticised the action of the Ministry of Transport, and announced their intention of making a special report to the House of Commons. This was done, and stated, *inter alia*, that the committee considered it would be in the public interest to allow the fullest possible participation by the railway companies in the service of road transport.

While, therefore, for the time being, the railway companies are unable to develop road motor services on the basis of Parliamentary authority, it would seem probable that very soon powers will be granted and the railway groups of Great Britain, which commence to function next year, will enter into strong competition with the independent road motor companies for the traffic abstracted from the railways, estimated on reliable authority at 6,000,000 tons per year.

Chilean · Railways

A general description of the Electrification of the first zone of the Chilean State Railway has already been given in these pages, when it was announced that the contract for this work was awarded to Errazuriz, Simpson & Co., a Chilean firm, all electrical equipment to be furnished by the Westinghouse Electric International Co. This contract included 39 electric locomotives. A description of the two types of passenger locomotives is given in the following article.

THE six Baldwin-Westinghouse electric locomotives, which are being built for express passenger service on the Chilean State Railways, will be capable of hauling 300 ton trains in either direction between Valparaiso and Santiago, without the aid of helper engines as is now necessary on the Tabon grade with steam operation. An elevation drawing of this locomotive is shown in Fig. 1. The locomotive will weigh 127 tons, and will have 105 tons on the drivers. It will have a nominal rating of 2,250 h.p., corresponding to a speed of 37 miles per hour at a tractive effort of 23,400 lb.



Express Passenger Locomotive — Fig. 1

The wheel arrangement will be 2-6-0 by 0-6-2, consisting of two main trucks, each of which has three driving axles and a two-wheel guiding truck. The cab will be of the single box type, and the motors will be geared direct to the driving axles. The general dimensions and weights will be as follows:

Classification	2-6-0×0-6-2
Length over buffers ...	67 ft. 4 in.
Length over cab ...	38 ft. 0 in.
Total Wheel base ...	48 ft. 4 in.
Rigid wheel base ...	14 ft. 5 in.
Diameter of driving wheel	42 in.
Diameter of guiding wheel	30 in.
Weight of complete locomotive	253,600 lb.
Weight of mechanical parts	160,000 lb.
Weight of electrical parts	93,600 lb.
Weight per driving axle	35,000 lb.
Weight per guiding axle	21,800 lb.

The trucks will be connected at the inner ends by a draw bar held in tension by spring buffers. The frames will be cast steel, bar type located outside of the wheels, connected by cast steel bumpers and cross ties, and carried on semi-elliptic springs over the journal driving boxes.

The cab underframe will be of rolled steel longitudinal members connected by cast steel and rolled steel cross members. M.C.B. couplers will be used with Continental spring buffers. Although eventually all drawbar equipment on the Chilean railways will be changed to M.C.B. standard, the Chilean freight cars now use the Continental type draw-hooks and for this reason the M.C.B. couplers will be provided with attachments for chain couplers.

The automatic air brake equipment will be the Westinghouse type 14-EL, a standard similar to that used on the present steam locomotives. With this equipment, straight air is available for handling the locomotive alone and the automatic feature for both locomotive and train.

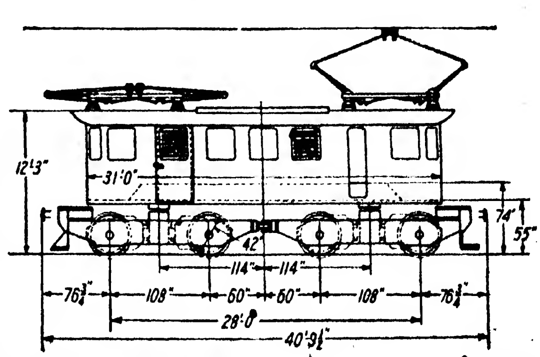
The express passenger locomotives will be equipped with six 275 h.p. driving motors, provided with field control and geared direct to the axles by Nuttall flexible spur gears. These motors are designed for operation two in series on 3,000 volts, and will be grouped in three speed combinations, all six in series for low speeds, three in series with two groups in parallel for two-thirds speed and three groups each with two motors in series for full speed.

There will be six running positions, the change from one motor combination to another being made by the shunting method of transition.

The control equipment is designed for operation of the locomotive from either end, and provision for regenerative electric braking is included. This enables the locomotive to return energy to the overhead system when descending grades. The main motor armatures will be connected in the same combinations when regenerating as when motoring, the excitation for the motor fields during regeneration being supplied by a constant voltage motor-generator set.

There will be two master controllers, one in each end of the cab, and the same controller will be used for both motoring and regulating. This controller will have four levers, with a total of 51 notches available in the three combinations. Westinghouse type HLF control establishes the main circuit connections by the use of individual unit switches operated by compressed air controlled by electro-magnetic valves.

Motor-generator sets will supply low voltage current for the control equipment, blowers and compressors. This is a two-bearing type of machine with a common frame for both motor and generator. The normal rating of the set is 35 kw. at 95 volts, with 3,000 volts at the motor terminals.



Local Passenger Locomotive — Fig. 2

The current collectors will be spring raised, air lowered and mechanically locked in the lowered position and controlled throughout by compressed air.

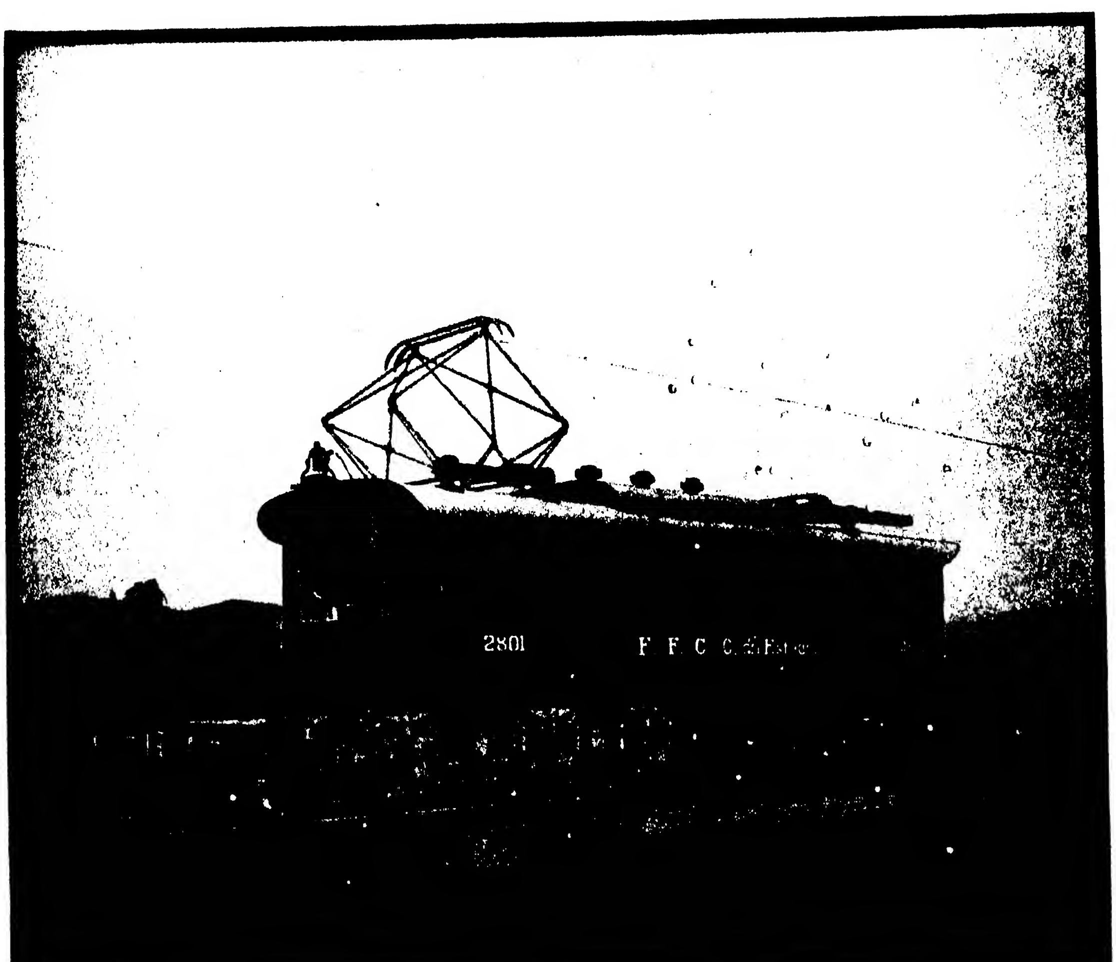
On level tangent track these locomotives will have a running speed of 61.5 miles per hour, when hauling a 300 ton trailing load. On the Tabon grade which is 2.25 per cent., the average running speed will be 33.5 miles per hour. The maximum tractive effort based on 25 per cent. adhesion will be 52,500 pounds, and the maximum speed 62.6 miles per hour. The range of speed in regenerative braking will be 12½ to 50 miles per hour.

In general appearance the eleven Baldwin-Westinghouse electric locomotives for local passenger service will be somewhat similar to the express passenger locomotives. An elevation drawing is shown in Fig. 2. This locomotive will weigh 80 tons, and the wheel arrangement will be 0-4-0 by 0-4-0. It will be capable of hauling a trailing load of 350 tons from Puerto to Vina del Mar, 260 tons from Vina del Mar to Llai Llai, and return, and 300 tons from Las Vegas to Los Andes and return. These locomotives will have a rating of 1,500 h.p., corresponding to a tractive effort of 15,600 pounds at a speed of 31 miles per hour. The maximum tractive effort under standing conditions will be 40,000 pounds, and the maximum speed will be 56 miles per hour. The cab will be of the single box type and the motors will be geared direct to the axles. The general dimensions and weights will be as follows :—

Classification	...	0-4-0 + 0-4-0
Length over buffers	...	40 ft. 9½ in.
Length over cab	...	31 ft. 0 in.
Total wheel base	...	28 ft. 0 in.
Rigid wheel base	...	9 ft. 0 in.
Diameter of driving wheel	... ...	42 in.
Weight of complete locomotive	... ...	160,000 lb.
Weight of mechanical parts	... ...	96,000 lb.
Weight of electrical parts	... ...	64,000 lb.
Weight per driving axle		40,000 lb.

The two trucks, each having two driving axles, will be connected at the inner ends by an articulated coupling in the form of a Mallet hinge. The frame and cab construction, the couplers and the brake equipment will be similar to the express passenger locomotives.

The local passenger locomotives will be equipped with four 275 h.p. driving motors, provided with field control and geared direct to the axle, with Nuttall flexible spur gears. There will be two combinations by connecting the motors in series and



General View of Electric Locomotive

in parallel, and additional speed variations will be obtained by varying the fields of the motors.

The control equipment is designed for operation of the locomotive from either end, but the grade conditions on the section of line on which these locomotives will operate does not justify the use of the regenerative braking feature. There will be two master controllers, one in each end of the cab, each controller having two levers, namely, speed and reverse, with a total of 23 notches available in the two combinations. The switching equipment duplicates that on the express locomotives.

The motor generator set will be a double armature machine, each armature consisting of a motor and a generator. The normal rating of the set will be 22.5 kw. at 95 volts, with 3,000 volts at the motor terminals. The current collectors will be the same as on the express passenger locomotives.

On level tangent track these locomotives will have a speed of 56 miles per hour, when hauling a 220 ton trailing load. The maximum tractive effort based on 25 per cent. adhesion will be 40,000 pounds.

A great many of the electrical and mechanical parts are interchangeable between the express and local passenger locomotives; and this will both facilitate the maintenance of locomotives and reduce the maintenance cost.

Alcohol as a Motor Fuel

FROM time to time we have commented in these columns on the investigations proceeding in various places as to the possibilities of using alcohol as a fuel for internal combustion engines. It will, therefore, be interesting to record that the Engineering Sub-Committee of the Empire Fuels Committee of the Imperial Motor Transport Council has recently submitted a most valuable report on this important subject. The report, which is of a highly practical character, describes a range of experiments, four series being carried out with 95 volumes per cent. alcohol, which is the strongest alcohol produced in commerce by the patent still. The tests included tests for power output and consumption, of power and efficiency, etc., and the result was to show that at all speeds, with both high and low compression, the thermal efficiency obtained with alcohol was higher than that obtainable with petrol or benzol at any compression which could be employed with them. Throttle tests indicated that the behaviour of alcohol and petrol under variations of throttle conditions is identical. It was proved, moreover, that under all conditions of compression, speed, or throttle, alcohol-driven engines run more sweetly and more smoothly than engines running on petrol. Detonation never occurred under any compression employed, but at 7 : 1 compression, corresponding to a pressure of 185 lb. per sq. in., there was a tendency towards pre-ignition; 6½ to 1 is probably the maximum comeprssion to be aimed for. The conclusions in the report are as follows:—

(1) Alcohol can be employed from the low compression employed on paraffin engines up to a far higher compression than can be used on any petrol.
(2) The thermal efficiency obtainable with alcohol is higher than with petrol or benzol.
(3) Under all conditions of throttle or mixture alcohol requires the spark more advanced than with petrol or benzol, and much more advanced with the weak mixtures.
(4) There was no evidence at any piston speed attained in the engine that the rate of combustion of alcohol under the conditions obtaining was too slow to obtain the maximum effect.
(5) Detonation does not occur at compressions up to 8 : 1, and pre-ignition does not occur at 6 : 1, even when running for long periods at the highest possible power output of the engine.
(6) There were no evidences whatever of corrosion in the engine.
(7) The power output and efficiency are increased by low temperature of the circulating water.
(8) Supplying heat to the carburettor reduces the power output, but slightly increases the thermal efficiency.
(9) Increase in the water contents up to 10 volumes per cent. is an advantage, particularly in very high compression engines.

It is stated that a further series of tests is now in hand to investigate the influence of ether on alcohol, and of alcohol on petrol, benzol, paraffin and the like. As the first introduction of alcohol on any large scale as a motor fuel will probably be in the form of an admixture with other ingredients, it is believed that the new investigations will prove of considerable value to the motor industry.

Should Railways be State Owned?

IN view of the perennial agitation in India, for the taking over of the railways by the Government, which would then exploit them on their own behalf, it is instructive to note an increasing tendency in other countries for the advantages of State ownership and operation to be challenged. There can be little doubt that, in certain places, public opinion inclines to favour the development of railways under private enterprise, and both in Switzerland and Germany, as well as other Continental countries, the question has become a very live one. The result of State operation of railways in Britain and America during the war was not so favourable as to incline the average native of those countries to view Government ownership with favour, and it has well been said that the dissatisfaction with the war-time arrangements has put back State ownership for at least a generation. The relative position has well been expressed by Mr. Hoover, the Secretary of Commerce in the United States, who stated that "no one who had observed the effect of Government management abroad, or at home, could contend that Government management could ever be as intelligent and efficient as private enterprise."

THIS SECTION IS PRIMARILY INTENDED FOR ENGINEERING STUDENTS AND DEALS IN SIMPLE LANGUAGE WITH THE CONSTRUCTION AND WORKING OF VARIOUS TYPES OF PRIME MOVERS AND INDUSTRIAL MACHINES AND DEVICES

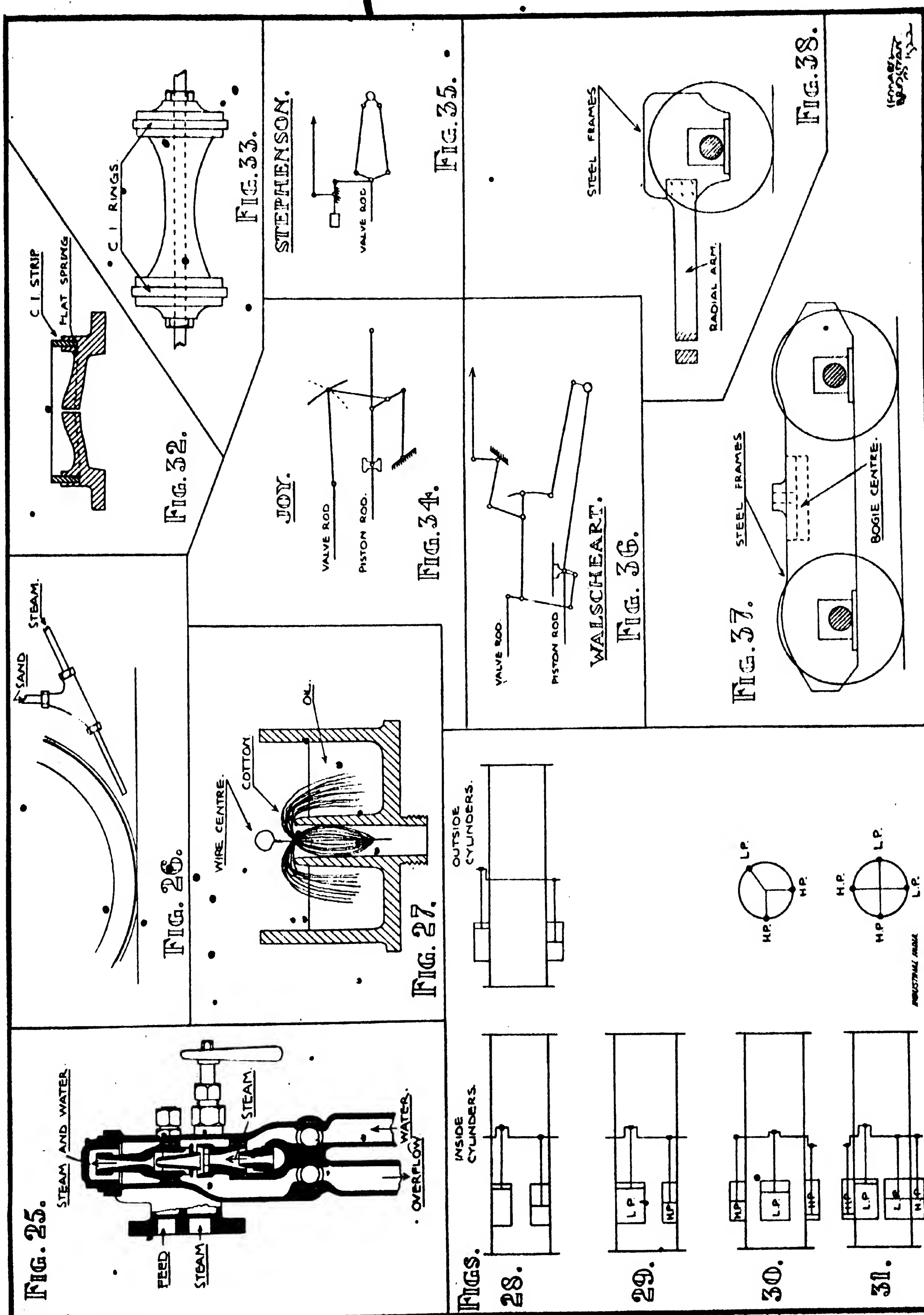
Small Talk on Railways (iv.)

SOMETHING might be said here with regard to the manner of forcing water in the boiler, when steam is up. This is done by generally two methods, either a more or less ordinary pump, or an injector. The principle of an injector is to utilize the steam in the boiler, by putting it through small cones, thus creating a suction action on the outside of the cones, and so drawing the water with it, finally delivering the water into the boiler. The excess of pressure necessary to do this, is caused by the high velocity of the steam as it passes through the small holes in the cones (sketch No. 25).

Perhaps some people have noticed when standing on a station platform, that the first two or three yards, after a locomotive first begins to draw a train out, there is steam apparently coming out from the lower side of the cylinder. This is caused by the driver allowing the cylinder cocks to remain open, one of these cocks is placed at each end of the cylinders, with the idea that should water accumulate in the cylinders, due to condensation, etc., then it can be got rid of by opening same. Should the cylinders not be fitted with such cocks, then the only thing that could happen, would be that when water did accumulate in them, the cylinder covers would probably be blown off, due to the fact that water cannot be compressed. Another interesting point that might be mentioned here, is the question of applying sand to the rails, in the case of starting, when the rails are slippery. This is generally done by the use of sand boxes placed somewhere on the platform, a pipe then runs from the box to a point in the front, where the wheel touches the rail. The old type of locomotives generally let gravity do its work, the driver in the cab opens the valve which controls this supply, and thus the sand runs down to the rail, but in the newer type, steam is utilized as well as gravity, in making the sand go on to the right place; the idea is more or less of an ejector type of simple principle (see Sketch No. 26), but the great trouble with this latter type, is due to the fact that they often get clogged up, owing to the steam condensing, and thus damping the sand. The lubrication of a locomotive is another most important point. Generally in all parts of an older type of locomotive which have to be lubricated, this is done by the aid of capillary attraction, but the newer method is to use forced lubrication on generally most of the points where required, the other points are lubricated as stated above. Force lubrication is merely a small pump, driven off one of the driving wheels, and from this pump are lead numerous small pipes away to the axle boxes, etc. There is no doubt that forced lubrication is a most effective system, and when once the locomotive stops revolving, then the lubrication stops. In the case of the capillary attraction lubrication, as on the older type of locomotive, the lubrication is either started or stopped by the driver when he leaves or returns to the shed. To do this he withdraws from all the oil cups the cotton wad (see sketch No. 27), and puts it down in amongst the oil, thus stopping any oil from running down on to the places where required. This capillary attraction is caused by the oil being sucked up by the loose ends on this cotton wad. and so running down the hole in which the cotton wad is pushed when about to commence the motion on the locomotive. A few words might be said here about the various types of cylinders which can be applied to locomotives.

1st. Simple type (sketch No. 28).
2nd. Compound type (sketch No. 29).
3rd. 3 Cylinder Compound type (sketch No. 30).
4th. 4 Cylinder Compound type (sketch No. 31).

All of the above types generally drive on to the one axle, the cranks are so arranged, except in the case of Type No. 1 and 2, that the turning movement caused by the steam is balanced. In the case of Type Nos. 1 and 2, the cranks of this locomotive are right angles to one another. Compound cylinders mean that into one cylinder of small diameter enters the high pressure steam, it then exhausts into the other cylinder of larger diameter, the ratio of the two diameters being in reverse ratio of the high pressure to the low pressure. With regard to the valves of a locomotive, which control the steam going into the cylinders, there are generally three types, the first and most simple is that of a D section, made in bronze, the great drawback to this type is the fact that the pressure of steam acts on the whole surface of its back, and therefore great wear on the sliding surface takes place. Another similar type is that of the same section, but on the back are fitted four strips of cast iron, which are pushed up against the cover of the steam chest by the use of springs. These strips therefore, cut off a large portion of the back area of the valve from the pressure of steam (sketch No. 32), other valves, in place of these strips, have an annular ring, which is also pushed up against the cover in a similar manner. The type which is now largely used is the piston valve, by this method, all the back pressure is done away with. The valves in order to make them steam tight, have fitted to them circular rings, also pushed outwards



Locomotive Details

by the use of springs. Generally this valve is made up of cast iron (sketch No. 33).

Referring to motion, generally speaking there are three types running to-day : "Joygear," (sketch No. 34), which is practically being eliminated wherever possible, "Stevenson" gear (sketch No. 35), and the last "Walschaert" (sketch No. 36). The latter gear more of the Indian locomotives have fitted to them. One of the beauties about this last gear, is that it is on the outside of the locomotive, and can therefore be easily got at. Regarding "Joygear," one of the defects of this is, that the parts are so heavy, that it wears itself out very quickly. Should one be standing on the side of a railway and listen to the exhaust of a locomotive, which is running under a fair load, you can always tell whether the valves of this engine have been correctly set; take the case of a simple cylinder engine, then what one hears should be practically a regular beat, four to one revolution of the wheels. In the case of a compound locomotive, the beat is two instead of four, in the same period of time.

Before leaving the various types of engines, a few words might be said again about the wheels. A Bogie is merely a frame work built up, has two axles (see sketch No. 37), therefore four wheels, and in most types of a locomotive this bogie is placed in front of the engine. Single wheels are generally called pony trucks (see sketch No. 38), or in some cases Bissel trucks. In this latter type the Bissel truck is merely a framework carrying the axle, this framework is connected by forged steel arms, to a pin, which is in the centre of the locomotive, and this can swing about to suit the type of road which the engine has to go over.

Reviews

"Research in Industry."

"Research in Industry" is the title of a recent publication which makes a very opportune appearance, this is by A. P. M. Fleming, C.B.E., M.Sc., M.I.E.E., and J. G. Pearce, B.Sc. (Eng.), A.M.I.E.E., and is published by Sir Isaac Pitman & Sons, Ltd., London, price 10s. 6d. net.

This little book covers the subject in a very comprehensive and obviously authoritative manner. Commencing with the basis of social progress; it deals with the Influence of Industrial Progress on Social Developments, the Application of Science to Industry, and the Fruits of Research. It then goes on to deal with the character of Research, both Academic and Applied, and their relationship to Industry. The next chapter deals with the Agencies for Research, such as National and Privately Endowed Institution, University Laboratories, etc. Chapter four deals with the Influence of Character and Conditions of Industry upon Research, dealing with the Factors Influencing Research in Industry, the Nature of Industry, etc. The following chapters are taken up with organisations for operating Industrial Research, such as design and equipment of Research Buildings; Co-ordination of Research, the Organisation of Intelligence, the Research worker, and finally the Nationalisation of Research.

It will be seen from the above headings that the authors have brought together inside of one cover the results of a great amount of labour in collecting such a wide range of facts on this important Industrial subject. It is probably generally recognised to-day that the common standard of living and labour is virtually dependent upon the efficiency of productive Industrial Processes, and such efficiency can only be maintained, and improved by scientific methods, as the authors state in an opening paragraph:— "Industry is in its simplest conception, merely the transforming processes, whereby natural resources are modified, through a series of operations, often extending over a period of years, into commodities required to satisfy the needs of the community." If, however, this process is to continue to provide for the ever increasing population of civilised countries, it is a matter of urgency that the methods by which Industrial Research is developed and brought down to a scientific basis, should receive the serious attention of all Industrialists.

The authors give some very interesting accounts of existing Research Laboratories, and methods already in existence, and give some very striking examples of what Research Work has done for the community. Quite apart from the practical usefulness of this publication, the reading of its pages is a fascination in itself, and shows in a clear manner what scientific progress really means.

The *Petroleum Year Book* 1922, edited by Sydney H. North, Association Institute P.T. London, "The Saint James's Press Co. Ltd.", 15 Henrietta Street, W.C.2. This new issue of the *Petroleum Year Book*, should be in the hands of every company and individual engaged, or interested in Petreloum. The facts and data given are helpful and enlightening, and admirable propaganda for extending knowledge on this increasingly important subject. The producer, the user, and the investor are all catered for, and should gain from a perusal of its contents. The Year Book, the only one of its kind, is not only a valuable work of reference, but may be studied by those only slightly acquainted with the various aspects of Petroleum, with considerable benefit. The contributors to its pages include such well known authorities as E. H. Cunningham-Craig, B.A., F.G.S., George Howell, F.G.S., J. Arthur Greene, M.Inst.P.T., J. E. Hackford, B.Sc., A.I.C., Harold Moore, M.Sc.Tech., F.C.S., Lieut.-Commander F. T. Addyman and A. H. Sproule, B.Sc. A new section appears in this issue giving financial and other particulars of British and European Oil Companies. The Year Book now runs to 400 pages compared with 250 of the 1921 edition, but the price of 10/6 and 11/3 post free remains the same.

SCIENCE

Conducted by A. H. HAVER, M.I.N.A. & K. S. DICKINSON, F.C.S.

THIS SECTION DEALS WITH THE APPLICATION OF SCIENCE TO INDUSTRY AND PARTICULARLY DEALS WITH APPLIED CHEMISTRY

Fallacies of the Cheese-Scoop

OUR fore-fathers had an implement which, about the years of grace A.D. 1750, and onwards was in great request. In appearance it was not unlike a small silver shovel, with the business end curved to about a third of a circle in its longitudinal axis. It was, and is, for the matter of that, known as a "Cheese-scoop," and its purpose in life was to be introduced into the central regions of a whole cheese, and in the withdrawal to extract a sample for testing by the prospective purchaser of the comestible.

The idea was excellent. By this means, no farmer, be he never so unscrupulous, could patch up a poor cheese with a top layer of good stuff, and hope that the buyer would not discover his mistake until the rectification of it was impossible. The cheese-maker could not possibly divine where the cheese-tester was going to insert his scoop, and this fact most probably was a very potent factor for good in the life of more than one dairyman whose deeds might otherwise have been evil. And so far as the testing of cheese goes, for aught that we know, the same method is in vogue to-day. There seems no reason why it should be discarded, nor does there appear to be any means whereby the crafty one may circumvent the cautious buyer. Therefore, in that case, there seems no necessity to devise a better way . . . . . for that particular article of commerce. But there are many other articles of commerce besides cheese. And there are many other methods of adulteration and sophistication beside the overlaying of a good article upon a greater quantity of an indifferent or frankly bad one. And whilst, for a homogeneous and solid article like cheese, such a method of testing may serve perfectly well, yet it is entirely fallacious when applied as a test to the thousand and one other articles which enter into the world's markets to-day.

A fair sample

But what we may describe as "Cheese-scoop" methods are still far too prevalent in the taking of samples from a bulk delivery, in order to have examinations or tests made. Too often by far, the taking of samples for the expert or the analyst is deputed to a junior of little or no experience, and the resultant information loses much on occasion, all of its value because the sample supplied does not conform with the average of the whole delivery. In modern commerce, sampling is an ever-increasing factor. Its rise and importance is *pied-a-pied* with the growth of sophistication in articles of commerce. As long as it is possible to admix spent cloves with fresh ones; dried tea leaves from the café with new ones from the plantation; exhausted strophanthus with potent seeds; shale with coal; and so on *ad nauseum*; so long will it be imperative that the best methods of analysis be known and regularly carried out. And as the first step in an accurate analysis, it ought to be thoroughly understood by the individual deputed to gather the sample, that he determines the whole value of the future report by his care or otherwise in gathering a sample that shall fairly represent the whole bulk of the material under discussion.

The usual method

But what actually happens? Only too often, a box (of what is devoutly hoped to be ample proportions) is filled from the first sackful that is reached, if the stuff is delivered in sacks, and sent off, as collected, to the trustful analyst. The sample is extracted, assayed, and the report sent in. Some weeks later, the poor man receives a protest that the bulk has not reached anything like the percentage yield that his report promised, and he is asked in effect "what about it." Let us quote a fairly recent case. A consignment of Cloves, weighing something like five tons, was purchased for distillation by a firm having a considerable business in flavouring oils. Before settling the deal, they sent a representative along to take a sample of the flowers for examination and analysis. He knew full well the purpose for which he was obtaining the sample, and returned with a cigar-box full—perhaps about a pound or so in weight. The sample appeared to be in order, and after inspection by the heads of the firm, and superficial criticism, was sent along for an assay to be made of the oil content. This by means of chloroform in a Soxhlet's extractor was determined to be 22.6 per cent. not at all a bad sample. Acting upon the information, and calculating that in this case the cloves would give a yield of something like 506¼ lbs. of oil per ton of flowers, the deal was concluded at a fair price. A month later, the analyst in the case received a letter wherein his figures were subjected to very severe criticism, and he was informed that the actual yield per ton of these cloves had been, not 506¼ lbs., but somewhere in the region of 380 lbs. Naturally, the technical gentleman was not content to leave the matter in that very unsatisfactory state, and he instituted a very vigorous enquiry as to the credentials of the sample with which he was provided. The result will already have been guessed by the reader; the person who collected the original sample was a junior member of the firm, who had never received any prior instructions as to the taking of samples, or the proper bulking of them before collection. He had simply opened several sacks, and taken a handful or two from each,

finally mixing the lot in his box by means of his fingers. No wonder the sample figured well, and we might add, no wonder the purchasers had their fingers burnt, for they deserved it, for their unbusinesslike methods. We repeat, that it cannot be too strictly instilled into the rising generation that the world is, most unfortunately, not yet peopled with an honest and an upright race (though we would be the first to pay tribute to more than one straight-dealing and honourable company and firm), and it behoves every commercial man in the present day to take the greatest care to see that when he takes a sample for analysis, he gets a sample that really does represent the general bulk of what he is offered.

The correct method

How is this consummation to be achieved? Well, it all depends upon what the goods consist of. If it be cheese, possibly the cheese scoop that formed the text for this paper would be as searching a test as any that could be devised. We do not know, for the analysis of cheese, except via the fifth and ninth nerves, at the festive board, has not been within our scheme of things. Two or three prods, in different directions, should surely give a fair sample of the whole mass. But if the goods be, say, coal? Here we have a somewhat awkward, bulky material. Probably there is no commodity under the sun that stands more in need of accurate teaching as to how sampling and bulking ought to be carried out. When one considers that there exists, in almost every grade of coal, a certain amount of unburnable material, slag, shale, stone, and what not, it must be obvious to all that very careful selection of the right proportion of coal to waste must be made, if an analysis is to be worth even the paper upon which it is written. Let us, then, outline fully how a correct bulking of a sample of coal should be carried out for the analyst. It must be borne in mind that he requires a reasonable quantity, if his results are to be reasonable accurate. A sample of coal weighing from ten to sixteen pounds is not at all too much, yet not uncommonly one receives specimens weighing not more than five to seven or eight pounds—a woefully short commons for accurate work.

Sampling Coal

How, then, is the dozen pounds or so to be selected? First, with a shovel, some of each sort of coal, lump, rubble, and small, should be collected in approximately the same proportions as it appears to be present in the total delivery. A total of a hundred-weight or more is not too large at this stage. Next, this sample should be broken quite fine with a hammer . . say into pieces sufficiently small to pass a one-inch sieve, or at any rate, not larger than a two-inch one. Then the whole should be intimately mixed with the shovel, on an iron plate, until there can be no doubt as to the evenness of the distribution of each sort of original coal throughout the mass. Then the whole should be squared into an even topped slab, and quartered, *by measurement*. The two *opposite* quarters should then be taken, and again mixed and quartered in the same way. This is repeated a third time, and if the size of the lumps is still sufficiently small to permit of the process being safe, a fourth time. The lumps are now further broken down, and the granular powder resulting is treated as before, until a sample of the requisite weight results. Thus, and thus only, are human errors eliminated to a large extent, and the sample so taken may with a very great expectation of success, be relied upon to give figures that will be realised when the bulk is employed in the time to come.

Except that there is usually no need to break up the sample, the same mixing and quartering process exactly should be employed in taking samples of most of the goods that are required to be submitted to analysis. The oil-bearing seeds and fruits; the resin-containing substances, such as Indian Hemp, Myrrh, Copal, and the like; the Alkaloid and so-called "Active Principle" containing plants and beasts; and all the host of substances which employ our time, energy, ships, and money, counting-houses in their commerce and distribution. Where the lumps are large, then the sample should be broken as a routine measure, where the masses are big, then they should be reduced in bulk before the mixing and dividing processes are carried out; and, last possibly, but by no manner of means least, where an inexperienced person is deputed to collect the sample, he should be carefully instructed in his duties, together with the why and wherefore of them, before he leaves the office. Better still, he should accompany a skilled person several times, before being entrusted along with this most important mission.

Scientific Instruments in Great Britain

There was recently formed in Great Britain the Institute of Physics, which gathers together all the leading men and associations engaged in the study of the constitution and properties of matter. One of the enterprises of this Institution is the founding of a journal to describe methods of measurement, and the construction and use of instruments to carry out these methods. This new journal will be of great value to research workers and manufacturers, and will also act as an incentive to the further development of scientific instruments—a field which has been cultivated already with much success by several British firms, whose names are known all over the world.

An Interesting Shipment for French Railroad Electrification

WITHIN a few weeks of the departure of the record-breaking shipment of apparatus for the Chilean Railroad electrification, another enormous train-load of electric railroad apparatus left the East Pittsburgh plant of the Westinghouse Electric and Manufacturing Company this month, for France.

The shipment, consisting of transformers and lightning arresters, was part of an order from the French Midi Railways which totalled well over a million dollars. The amount of the apparatus in the shipment, which weighed approximately eight hundred tons, can be estimated by the fact that thirty-two railroad cars were required to transport it. The material went by the Pennsylvania Railroad to New York, and shipped from there to Bordeaux.

The order was of more than ordinary interest, because it covered material for the first system outside of the United States to adopt 150,000 volts for its main transmission.

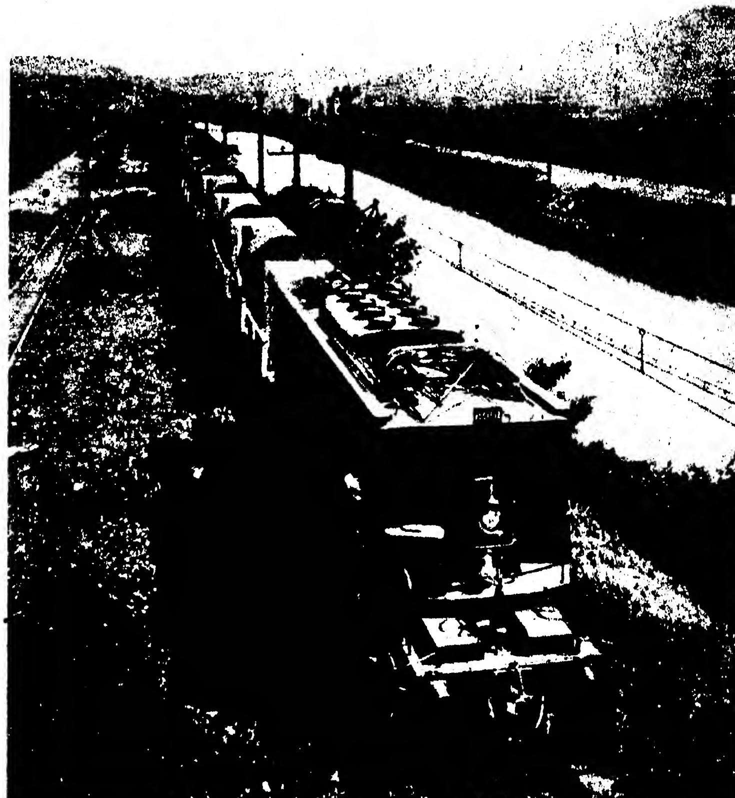
The lines of the Midi Railways are mostly located in the South of France, north of the Pyrenees. As far back as 1906 the management of the railways commenced an exhaustive study of the electrification of this part of their system, having in mind the utilisation of the water power available on the northern slopes of the Pyrenees. By 1914 four sections had been electrified with single phase current at 12,000 volts and 16.67 cycles, but all work was stopped at the outbreak of the war.

The French, early in the war, lost practically all their coal-fields to the Germans. This, more than anything, emphasised the necessity of developing the water power resources of the country and electrifying the railroads wherever it could be economically done. Thus, on the cessation of hostilities, one of the first acts of the Government was to send a technical commission abroad to study existing railway systems.

The commission, after visiting Switzerland, Italy, and America, recommended that 1,500 volts, direct current, be adopted as the standard for the electrification of all French railroads, and the Midi Railways Company, in conformity with this decision, immediately resumed the work interrupted by the war on this new basis. The sections already electrified at 12,000 volts will be changed to 1,500 volts direct current, so as to have a uniform system throughout.

The power will be generated in six stations or groups of stations capable of developing a total of 362,000 h.p., the stations being put up progressively as the different sections are electrified. The head of water varies from 350 feet in the station with the lowest head to a maximum of 2,500 feet. Power is generated at 8,000 volts and 50 cycles, and is distributed to the railway sub-stations over a 60,000 volt three-phase distribution system, distant points of the distribution system being connected by 150,000 volt transmission lines.

The railway sub-stations, which are located along the railroad at intervals of 12 to 18 miles, are connected directly to the 60,000 volt distribution system. They all contain rotary converters, with the exception of a few in which mercury arc rectifiers will be used.



A Train-load from the Works

The equipment for the generator stations, the distribution system, the railway sub-stations, and the locomotives, will be built in France. The work entrusted to the Westinghouse Company comprises a large part of the 150,000 volt transmission system, including the transformers, synchronous phase-modifiers for the voltage control, and the relay protective gear.

For the initial development three generating stations will be utilised. The 150,000 volt lines will connect these with the distant cities of Pau, Dax and Bordeaux to the West, and Toulouse to the East. At the generating stations 20,000 kv-a. banks made up of Westinghouse single phase two-winding transformers will raise the voltage from 60,000 to 150,000 volts. At the sub-stations near these cities the transmission system connects again with the distribution system through step-down transformer banks of 20,000 kv-a. made up of Westinghouse single phase three-winding transformers, lowering the voltage from 150,000 to 60,000 volts. These transformers have a third winding of 6,600 volts for feeding Westinghouse synchronous phase modifiers.

These machines are intended to automatically keep constant the voltage at the sub-station irrespective of the load. Owing to the length of the lines and the high voltage of the transmission, they are designed to cover a wide range of reactive kv-a. At Bordeaux, there will be two-phase modifiers each of 15,000 kv-a. capacity and 7,500 kv-a. lagging capacity. At Dax and Toulouse there will be in each two machines of 8,000 kv-a. leading and 4,000 kv-a. lagging capacity. All these phase-modifiers are equipped with the Westinghouse patent automatic voltage regulator designed to cause the machine to give the right amount of reactive kv-a. leading or lagging required to keep the line voltage constant.

The Westinghouse Company, in conjunction with the engineers of the Midi Railways, worked out a complete scheme of relay protection embracing the generator, distribution and transmission. The generators and transformers are individually protected differentially, that is, they are automatically taken off the line in case of internal trouble.

The transmission and distribution are so laid out that the supply to the railway sub-station is assured. The lines are therefore for the most part in duplicate, except where sections are fed from both sides. Where the transmission lines are in duplicate, they are equipped with balanced line protection by means of the recently developed Westinghouse directional relay, which does not require potential transformers. The whole relay scheme is so laid out that in case of trouble in any section of line or piece of apparatus the part in trouble is isolated without interrupting the supply to the rest of the system.

The whole order, of which this shipment forms a part, covered twenty-five single-phase transformers of 6,667 kv-a., two synchronous phase-modifiers of 15,000 kv-a., four of 8,000 kv-a., thirteen 150,000 volt lightning arresters, and a large number of relays and current transformers.

High Operating Costs on the G.I.P.

IN the June issue of INDUSTRIAL INDIA, we briefly referred to the results of the working of the Great Indian Peninsula Railway, during the half-year ending September 30th, 1921. The financial position was then not at all satisfactory, and little improvement has been effected during the ensuing half-year. At the 145th half-yearly general meeting held in London last June, Sir Charles H. Armstrong, the Chairman, stated that the percentage of working expenses to gross receipts for the year ending March 31st, 1922 was 91.49, " a very excessive figure, which must and will be reduced in the current year."

This high operating ratio has been accounted for, to some extent, by heavy charges for maintenance of way, bridges, etc., and for wagon repairs, while there has also been a greatly increased expenditure on coal. In short, the expenditure for the year was 12.57 crores, against 10.64 crores during the previous year, an increase of 192½ lacs, or 18.08 per cent. Gross earnings on the amalgamated system were 13.74 crores, or a decrease of 9½ lacs on the previous year. The net earnings were, therefore, 101 lacs, or 7.94 per cent. of the gross receipts, but with certain essential adjustments this credit item was turned into a deficit of 240 lacs, which is the result of the year's working.

Small wonder that the Chairman, after analysing the position, stated very definitely that economies under all heads were imperatively necessary, and all capital and renewal expenditure which could be avoided must be avoided until equilibrium was reached. A Commission of Inquiry has been closely investigating the methods of working in India, in order to ensure the utmost economy, and it is hoped as a result of their endeavours materially to reduce the permanent expenses.

The Itarsi - Nagpur connection, which has been under construction for many years, is rapidly approaching completion, and it is hoped to be able to open the line for through traffic early next year. Another important improvement upon which construction is proceeding is the doubling of the line between Shegaon and Nagpur, the completion of which will enable the company to handle with facility the large traffic in these areas. The Harbour Branch extension, which is of the utmost importance in connection with the new Bombay trade depot at Sewri, and to the suburban traffic generally is also being pushed ahead, and will eventually prove of great advantage.

Water Terminal Equipment

IN past issues of "INDUSTRIAL INDIA," we have dealt at some length with the problems involved in effective and economical port working, and in subsequent issues hope to go further into this important question. That it is of the utmost importance will be recognised by all who reflect upon the tremendous delays and consequent expenditure involved by inadequate facilities at "water terminals" to use an expressive Americanism. A point of interest to which our attention has been drawn is the tendency nowadays to abandon the use of long quays and to substitute therefor moderately long jetties, which have the twofold advantage of affording easy access for ships, and of enabling railway communication more easily to be given. The new Albert Dock extension at the Port of London, is one instance where the jetty system has been adopted, while oblique jetties have been built at Dunkirk, where the length, 1,970 ft., is almost ideal for the rapid handling of traffic. In this connection, mention may be made of the fact that there is an undesirable tendency in certain localities to make the jetties longer than is economically useful. This should be guarded against, as the maximum efficiency can usually be gained from jetties of adequate length, yet sufficiently short to enable free and rapid access to all quays by means of simultaneous and almost continuous shunting operations.

INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

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BETWEEN OURSELVES

Textile Developments in India

THAT the Textile Industry in India is rapidly developing, is admitted on all hands. In fact, so much is this so that more than one great corporation has carefully considered the desirability of transferring to, or, at least, of establishing plant in India. On this point, it is, therefore, worthy of notice that the British Calico Printers' Association, after receipt of a report from a special investigator who has visited India, and studied conditions on the spot, has definitely decided that any expansion of the C.P.A. activities shall take place in Lancashire. There were many good reasons to urge in favour of development in India — the saving of transport costs, which form an appreciable percentage of working costs, the attitude of India towards imported cotton goods and others, but despite these advantages the special commissioner who carried out an intensive investigation of the problem reported that the balance of advantage lay in favour of development along established lines. The undeveloped state of India in a manufacturing sense, the difficulty of obtaining a supply of reasonable coal within a convenient distance, the question of an adequate supply of running water, and the absence of trained personnel were factors taken into full consideration. There are other reasons as well, but these are so obvious as to need no elaboration.

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Burma Oil

AT the twentieth annual general meeting of the Burma Oil Company Limited, Sir John Cargill, the Chairman, was able to give the shareholders a very reassuring address on the year's working. When it is added that a dividend of 30 per cent. on the full year, free of income tax, was declared it will be clear that there was little room for pessimism; but Sir John had one or two things to say that are worthy of record in these columns. He pointed out that increased taxation arising out of the current Indian Revenue Act was going to add to their producing costs and that this might make it economically and commercially difficult if not impossible—for them to maintain their maximum price policy for kerosene in India. Sir John also referred to the drilling operations in India and Burma, and gave reasons to show the necessity for deeper and more expensive drilling operations. He explained the impossibility of standing still, and urged that they must submit their geologists' reasoned views to the test of the drill if they were to progress. Otherwise, *the discovery of still unknown productive areas in India* might undermine the predominant position they occupied as a marketer, as well as a producer, in India. Reference was also made to the provision of facilities for bulk petrol in the Bombay area, and Sir John pointed out that the successful arrangement of this had enabled them to reduce the price of petrol in the Bombay sphere.

* * *

Electricity Supply Organisation

IN another note we have referred to the arrangement by which the Calcutta Tramways will in future be operated by means of current purchased in bulk from the Calcutta Supply Company, and it may therefore be interesting briefly to show how an area of 1,400 square miles in the North-east of England is served in this way by one organisation.

Originally there were several supply companies, but they are now amalgamated, so that there are now over twenty power stations linked up in the system. Seven of the power stations are coal-fired, and the remainder are partly or entirely utilising waste heat for generation purposes. In all, there are some 400 sub-stations, at which high-tension current is transformed to a pressure suitable for small motors, etc. While the horse-power connected in 1905 was 52,000 for bulk and miscellaneous, 52,000 for collieries and mines, 50,000 for traction purposes, and 40,000 for heating, cooking, small manufacturers etc., this had grown in 1920 to 470,000 for bulk and miscellaneous, 442,000 for collieries and mines, 316,000 traction and 282,000 for lighting, heating and small manufacturers. Thus, in 1905, the total horse power connected was 194,000, whereas in 1920, it was 1,510,000. That great economies have been effected by the amalgamation of the separate interests is indisputable, while consumers have gained from the cheaper and more efficient supply of power.

* * *

The Calcutta Tramways

THAT tramways are the best and most economical means of dealing with the traffic needs of the dense population of Calcutta, is a statement made by Mr. J. G. B. Stone, in his speech at the recent general meeting in London, of the Calcutta Tramways Company, Limited. Mr. Stone also observed that the motor omnibuses, which were put in service in August 1921, had not realised expectations, the results of the service having proved disappointing. For the time being, therefore, these vehicles are being kept for special traffic purposes. In connection with power supply it is interesting to note that while, in the past, the Company has generated its own electricity, they have now entered into an agreement with the Calcutta Supply Corporation to purchase current in bulk. There can be little doubt that this is a sound

policy, and one that is gradually being extended under suitable conditions in all parts of the world. It essentially makes for economy, and is to be recommended. The net earnings of the Company for the year were £64,429 as against £240,389 the previous year, this decrease being due, the Chairman stated, mainly to strikes and political disturbances, there being during the year 57 days of actual stoppage. Further rolling stock has been ordered and will soon be in service, and it is hoped that the current year will witness an improvement.

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Bombay, Baroda and Central India Railway

The working of most of the Indian Railways for the year ending March 31st, 1922, has shown an increase in the operating ratio as compared with the previous year, and the Bombay, Baroda & Central India, is no exception to the rule. At the same time, they have been relatively fortunate, as compared with certain other lines, although the working expenses were 76.97 per cent. as against the previous year's 68.09 per cent. The system of railways worked by this Company comprises 3,641.55 miles, 1,230 miles being 5 ft. 6 in. gauge, 2,343 metre gauge and 69 2 ft. 6 in. gauge. The gross earnings were Rs. 10,32,38,837, an increase of Rs. 35,11,274, but as expenditure was Rs. 7,94,67,047, or Rs. 1,15,59,845 more than the previous year, the net earnings were Rs. 2,37,71,790 or Rs. 80,48,571 less. Six per cent. is being paid, as in the previous year, but to do this about £30,000 has had to be taken from profits held in reserve in the stockholders' revenue account. With regard to traffic there was a decrease of, roughly, 1,000,000 passengers carried and an increase of 300,000 tons carried, although the ton-mileage worked was less. On the whole, considering the high figures incurred for locomotive fuel and maintenance of way, the results were satisfactory, and it is probable that improvement will be realised in the current year.

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Indian Railway Gauge Problems

In a recent issue of Industrial India, we published a summary of Mr. F. G. Royal Dawson's paper on "Indian Railway Gauge Problems," read at a meeting of the Institution of Civil Engineers in London. Since then, Mr. Royal Dawson has contributed a somewhat similar paper to the proceedings of the Royal Society of Arts, and one or two of his views have led to some criticism. At the same time the concensus of opinion in the discussion participated in by several authorities was that Mr. Royal Dawson's suggested gauge policy was eminently practicable. One speaker, however, urged that as India was an entity, the question of gauge, except in so far as it affected the country itself, was not important, but this surely took a short-sighted view of the possibilities of the future. When, by means of the Nushki route, the Khyber Pass, the Yukong Valley and the Northern Shan States, India is linked up with Trans-Caucasia, Russia and China respectively, the gauge problem will be intensified unless attention has been paid to these developments as they progress. The great thing is to avoid a break of gauge wherever it is possible to do so, and both in India and Australia, they have suffered so tremendously from lack of a coherent policy in this regard that the lesson should not be lost on those now responsible for Railway developments.

* * *

Steam and Electric Refrigerating Plants

An instructive article on steam and electric driven refrigerating plants is contained in a recent number of "Power" (U.S.A.), by Mr. G. E. Porce. A refrigerating plant can be driven in one of three ways, (1) Electricity purchased from a central station, (2) Steam power plant, and (3) Oil engine. The latter has many advantages when electric power at a reasonable price is not available, and is being more and more adopted since its reliability is now recognised. The question of the use of electricity is largely a matter of the price to be paid for the current, and has of course, the advantage as compared with a steam plant that all troubles with coal, ash, water, steam pipes, condensers, and the attendant labour, are done away with. There is, however, the difficulty that electric supply is liable to interruptions, a very serious matter in a refrigerating plant. Also, in order to get current at the most favourable rates, it is necessary to take a steady load, which means having a very large ice storage capacity, an expensive item.

The chief advantages of a self-contained and independent steam power plant on the usual lines are great flexibility in power output, a continuous service free from breakdowns, and complete control independent of any outside authorities. In an ice plant continuous service is even more important than running efficiency. Also the modern medium speed steam engine is more economical than the average electric motor under the ordinary conditions of an ice factory.

A valuable and detailed comparison is given of the figures of a steam and electric driven plant. Thus, on two almost identical plants, with a capacity of 100 tons of ice per day, and a storage capacity of 10,000 tons, the cost of the steam driven plant was $36,000 for the ice plant buildings and daily storage, $80,000 for the large storage buildings, and $84,000 for the ice-making plant and machinery complete, making a total cost of $200,000. The total cost of the ice produced was $1.97 per ton, including 80 cents for interest, taxes, depreciations, and maintenance charges, 72 cents for labour, and 45 cents for coal, water and supplies, coal being $6.00 per ton. A similar plant, electric driven, with current at 1¼ cents per K.W. hour, cost $185,000 complete, slightly less than the steam plant, including $32,000 for the ice plant buildings and daily storage, $80,000 as before for the large stores, and $73,000 for the complete ice-making plant. The total cost of the production of ice was, however, considerably more than with the steam plant, $2.23 per ton inclusive, consisting of 74 cents for interest, taxes and depreciation and maintenance charges, 59 cents for labour, and 90 cents for electric current. There is no question, therefore, that the steam plant has the advantage, and much the same state of affairs probably obtains throughout the world.

Sugar Industry

Commencing in the next issue of Industrial India, will be the first article of a short series on Sugar. The first article will deal with the present state of the Industry, and what is being done for the future; and the subsequent articles will describe modern machinery used in the Industry.

INDUSTRIES

Conducted by FRANK DAWSON.

THIS SECTION DEALS WITH THE GREAT BASIC INDUSTRIES OF INDIA. IN THE PRESENT ISSUE WE DEAL PARTICULARLY WITH IRRIGATION

Irrigation Enterprise in India

The following is the first portion of Mr. Wood's paper read before the Indian Section of the Royal Society of Arts, and which deals with the History and Commercial development of the Indian Irrigation system. In our next issue we will publish a summary of the remaining portion of Mr. Woods' paper, in which he condemns the Sukkur Barrage project.

THE total area of the British Provinces in India and Burma (*i.e.*, to say, of territory directly administered by British agency) amounts to about 625 million acres, or more than twelve times the gross area of Great Britain.

Of this area little more than one-third, *i.e.*, about 223 million acres, is cultivated and sown annually; whilst little more than one-fifth of the cultivated area is artificially irrigated. The remaining four-fifths of the cultivated area is dependent upon rainfall for its germination and maturity. If in any season, in any locality, the rainfall be deficient, the crops fail and the local population suffers distress; whilst a succession of two or more seasons of drought results in famine.

1. Of the gross area of 49 million acres, which is irrigated artificially, about two-thirds, or over 30 million acres, are irrigated by means of canals or reservoirs (tanks); the rest being irrigated with water drawn from wells, or by other miscellaneous methods. The canal systems of irrigation are mostly administered by official agency, and they irrigate annually more than 20 million acres.

2. Of the area irrigated by canals, about half, or about 10 million acres, lies in the Punjab Province; about one-sixth in the Sind portion of the Bombay Presidency; about one-eight in Madras, and another eight in the United Provinces; and one-tenth in Behar and Orissa. From an irrigation point of view, the Punjab is the most important Province in India, and it is there that canal-irrigation, and especially perennial irrigation, has exhibited some of its most striking successes both scientific and financial. It is as one who has controlled the canal administration of the Punjab quite recently, for several years, that I venture to address my present audience.

The Punjab

3. The Punjab Perennial Canals have proved to be most remunerative undertakings. The capital expenditure on them, down to the end of the year 1919-20, amounted to nearly £16,000,000; and the gross revenue derived from their operations amounted, in that year, to nearly £3,300,000; the nett revenue to the State, after deduction of working expenses (£800,000), amounting to nearly £2,500,000; or, to say, 16 per cent. per annum on the capital expenditure. The annual interest charges on capital amounted to £488,000; and when we have deducted these charges from the nett revenue, we find there is still left to the Government a nett profit of 12½ per cent. on the total capital cost of these works.

Figures like these are calculated to fire the imagination of officials, and even of non-officials, in the agriculturally less prosperous provinces of India; and it seems to be the case, unfortunately, that a contemplation of the successful results of Punjab Irrigation enterprise has led to a degree of excessive optimism, in an adjacent province, which it is my desire to moderate, if possible, by the considerations set forth in the present discourse.

4. The conditions of perennial irrigation enterprise in the Punjab are at present extremely satisfactory; but it is well to bear in mind that they were not always so; for it would be a grievous mistake to suppose that any kind of project of perennial irrigation—prepared without the engineering skill, and the prudence of agricultural and financial forecast, which have been the outcome of slow evolution and experience in the Punjab—is bound to prove successful, without regard to considerations of geodesy or of hydrography, or of hydraulics, or to any consideration, but that of meteorology in a country of scanty rainfall.

5. British enterprise in the development of irrigation in India began with the restoration of the Western Jumna Canal in the year 1820. Previously there had been a canal which had been constructed by the Emperor Firoz Shah, of Delhi, in the middle of the 14th century. This canal offtook from the River Jumna, near its exit from the Sivalik Hills and flowed a distance of about 200 miles to the Fort of Hansi and the town of Hissar, on the borders of the Rajputana Desert. It ceased to flow after an existence of about 50 years, but was restored about the middle of the 16th century by the Emperor Akbar, and was improved further, about the middle of the 17th century by the Emperor Shah Jahan, who conducted a branch from it to the city of Delhi. It fell into ruin or disuse a century later and was once more restored in 1820 by the British Government, who, however, made no alterations in the alignments, or noteworthy improvements in the design of the canal system.

6. From 1820 onwards, the tracts watered by the canal experienced alternately, from time to time, visita-

tions of famine in years of scanty rainfall and of epidemic malaria in "wet" years; and it is noteworthy that the abundance of water supply in wet years was as disastrous to agriculture as the shortage thereof in years of drought quite apart from considerations of human morbidity or mortality.

7. The general result of all the discussions of the waterlogging problem which resulted from their ill effects was that in the years 1871 and 1874, 50 years after the restoration of the old *Badshahi* Canal, the Secretary of State for India sanctioned estimates, amounting to over one crore of rupees (£10,000,000 at the then rate of exchange) of the probable cost of re-aligning and re-modelling the Western Jumna Canal. A very extensive system of surface drains was also included in the project which was carried out to completion by the year 1885.

This expenditure had the effect of reducing the net revenue from 37½ per cent. per annum on capital cost to 5½ per cent. per annum, and the consent of the Government to this reduction of net profits was an index of its realisation of the gravity of the waterlogging evil.

Karnal to Sirsa Branch

In the year 1889, also, the Secretary of State for India sanctioned a project for the construction of a new branch of the Canal, extending from above Karnal, to Sirsa, a distance of 140 miles, thereby greatly increasing the area over which the water of the canal was dispersed in irrigation, and reducing the intensity of irrigation per unit of the gross area commanded.

8. The result of these measures has been excellent. The area irrigated annually by the Canal, which averaged about 400,000 acres during the period 1860-1880, and which dwindled to less than 300,000 acres a few years later, now averages about 750,000 acres annually.

This irrigation, moreover, of 750,000 acres, is dispersed over a gross area of 2,700,000 acres; and the water-logging evil in the Western Jumna Canal tracts disappeared with effect from about the year 1895, or 75 years after the re-opening of the old *Badshahi* Canal by the British.

9. Irrigation canal science was still backward, and the Punjab Canals were still in trouble at that date, from various causes. The Sirhind Canal was opened for irrigation in the year 1882, but suffered seriously from deposits of water-borne sand, which accumulated in shoals to such a height that by the year 1893 the question of closing the canal for three months annually during the silting season, was seriously mooted and agreed to. Later on, however, a remedy was found for this shoaling trouble, but not till the year 1901.

Water-logging Trouble

Meanwhile, the Bari Doab Canal, which had been opened for irrigation in the year 1859, experienced the water-logging trouble in its upper reaches; so that in the year 1892, winter, or *rabi*, irrigation from it was discontinued in the District of Gurdaspur and part of Amritsar. This trouble is still in being, and is very much in evidence in years of abundant rainfall. Around the city of Amritsar the ground water lies at a level only about 5 feet below ground surface at ordinary times, and heavy rainfall brings it up to the surface.

In 1887, the (Lower) Chenab Canal was opened for irrigation, but proved a failure by reason of defective design. It had been designed to draw water perennially from the River Chenab without the help of a regulating weir across the river, but the design was defective for that purpose, and silt-deposits put the canal out of action in the autumn. A weir was built across the river at its head in the year 1892, and the scope of the canal system was vastly increased and brought into effect by the year 1902, since when the history of the canal has been an uninterrupted record of financial success.

10. The year 1901, 81 years from the inception of British irrigation enterprise in India, marks the date from which the success of all the perennial canals of the Punjab has been fully assured; but the troubles and difficulties through which that enterprise has forced its way ought not to be overlooked in any new schemes that may be devised now or hereafter. These canals have been commercially successful because they were designed with caution, in the light of agricultural and financial considerations, as well as from the point of view of engineering construction; but failure may yet overwhelm any projects, apparently similar at first sight, but essentially different in underlying conditions, if such projects be conceived in a spirit of undue optimism, or in ignorance of the essentials requisite to success in such undertakings.

11. The great rivers of Northern India, the Ganges and the Indus, and their tributaries, the Jumna, and the five rivers of the Punjab, at the points where they issue from the Himalayan Mountains, on to the alluvial plains, discharge volumes of water varying from 2,000 to 10,000 cubic feet per second in the winter or low water season, up to from 30,000 to 450,000 cubic feet per second ordinarily in the summer, or flood season; whilst extraordinary floods of short duration, due to heavy rainfall, occasionally raise the discharges up to from 200,000 to 1,000,000 cubic feet per second.

12. THE SUB-MONTANE ZONE.

At the points where these rivers issue from the Himalayas, the ground surface of the plains usually slopes away from the hills at the rate of from 10 to 25 feet per mile. Floods of such magnitude, flowing with velocities generated by such steep gradients, have an erosive force far greater than any soil but rock can withstand; hence, in the sub-montane regions, the currents of the rivers erode their channel-soil in the vertical as well as in the horizontal planes; and boulders, in all sizes, from shingle up to stones several feet in diameter, forming the bed of the stream, indicate the erosive power of the currents. Where the rivers issue from the Hills, they are usually from ¼ to ½-mile wide; but as they progress down stream, they widen out, by process of lateral erosion, until, at a distance of 50 or 100 miles, or so, downstream, their valleys, formed by erosion, are anything from one to ten miles wide.

The Lower Regions

13. THE LOWER EROSIVE ZONE.

At this distance from the Hills, the declivity of each river bed has usually flattened to about 1½ feet per mile, and the boulders and shingle of the bed-soil further upstream have given place to coarse-sand and silt formations. In this region, which we may describe as the Lower Erosive Region, the width of channel or valley eroded by the currents, is far greater than any but the greatest and rarest floods can occupy; so that, ordinarily, even in the summer, or flood, season, the river occupies only a fraction of the width available for it. It flows in one or more main channels, and usually several subsidiary channels, with

shoals or reed-grown islands between them.

14. If we draw a line at right angles to the course of the river in the Lower Erosive Zone, and survey the ground levels along that line, we find that although the High Flood Level of the river is high enough to submerge the whole of the riverain, or lowlands, in the valley, it is yet well below the levels of the up-lands which set lateral limits to the riverain. This is the distinctive feature of the Lower Erosive Zone, to which I particularly draw attention, as bearing on the problem of irrigation. The lowlands are known as *Khadir*, or "hidden," in allusion to their liability to be covered with sheets of water, or with dense vegetation, during the flood season. In the Punjab vernacular they are also known as *Hithar*, or Lower. The up-lands are known as *bhangar*, or *utar*, the latter word meaning "up-land."

Silt Deposits

15. The Upper Deltaic Zone.

The erosive action of the currents in the Lower Erosive Zone tend to flatten the declivity of the river bed; so that, as the river progresses downstream, the erosive action decreases, and a tendency to deposit silt and sand by alluvial action becomes more and more pronounced.

The bed of the river, and the level of the riverain land, gradually rises; and the relative elevation of the uplands diminishes.

In the Punjab this occurs in the region immediately upstream and downstream of the confluences of its rivers with each other and with the Indus; which region we may describe as the Upper Deltaic Zone. In this zone the river tends to occupy, generally, one main channel, which, by alluvial deposit, raises itself gradually higher; so that the riverain land, formed by alluvial deposit from the river's floods, becomes a well-defined ridge, with the river located along the top of the ridge, and the ground surface sloping away downwards on both sides, towards low-lying valleys. Under such conditions, it is obvious that there is a considerable possibility of the river's breaching its banks during some high flood, and deserting its elevated channel on the ridge, for another at a lower level in the lateral valley.

16. The Lower Deltaic Zone.

Finally, as the river progresses further down stream, it arrives at the true Deltaic formation, in its approach to the sea. At the head of this "delta" it splits up into two or more channels, each of which, forming for itself an ever more and more elevated ridge of alluvial deposit, flows into the sea by a separate "mouth."

17. River Gradients.

We see, then, that if a section were drawn along the bed of a North Indian River, in the vertical plane, the bed line of the river would appear as a curve, of gradually varying curvature, sharper upstream and flattening out downstream, nearly tangential to the vertical at the upstream end, and near tangential to the horizontal at the downstream end.

18. The canals of Lower Egypt, and of Madras, are examples of irrigation canals in the Lower Deltaic Zone, IV. Those of Middle Egypt, Sind and some of the Punjab Inundation Canals may be classed in the Upper Deltaic in Zone III.; whilst the rest of the Punjab Inundation Canals occur in the Lower Erosive Zone, II. The perennial canals of the Punjab and the United Provinces of India offtake from their parent rivers in the Sub-Montane and Lower Erosive Zones I. and II.

19. It is well to bear in mind the difference, in natural conditions, of relative elevation of water and of ground surface in Zones IV., III., and in the riverain lands of Zone II., from those of the uplands in Zone II.

In Zone I. it is hardly necessary to raise the water level of a river, even in the low water season, by means of a barrage or weir across the river in order to ensure a constant supply of water to offtaking canals. It is in Zone II. chiefly that the necessity of raising the water surface of the river, whether in the high-water season or in the low-water season, in order to irrigate the uplands, above the level of the river's highest floods, has been felt, and has led to the construction of the great river weirs of the Punjab and the United Provinces.

In Zones III. and IV., though weirs or barrages may be built across rivers, in order to raise their low-water levels for purposes of irrigation (as has been done in Madras, Behar, and in Egypt), such construction is a luxury rather than a necessity; and it depends upon the particular circumstances of each case whether the country can afford the luxury.

20. Punjab Irrigation History Since 1901.

It is probable that the high-water mark of irrigation-canal-enterprise on the part of British engineers in India was reached by the completion of the Lower Chenab Canal project, in the year 1902, at a cost of about £1,800,000 (270 lakhs of rupees). It was then irrigating annually 1,900,000 acres of land; an area which has since increased to about 2,400,000 acres annually. Its full capacity is nearly 11,000 cubic feet per second (about six times the average discharge of the Thames at Teddington), and it yields a net revenue that represents a return of nearly 45 per cent. per annum on its capital cost.

The completion of this canal was followed by that of the Lower Jhelum Canal, a similar, but much smaller, canal, which yields a nett revenue return of more than 20 per cent. per annum of its capital cost.

Next followed the great Triple Canal project, of greater magnitude and far greater cost, but not nearly so remunerative as the Lower Chenab Canal. The Triple Canal project was completed in about the year 1916 at a cost of about £6,900,000 (1,033 lakhs of rupees).

When fully developed it is expected to yield a nett revenue return of about 8 per cent. per annum on its capital cost; but at present its yield is only about 5 per cent.

THE ROTASCOPE

The National Physical Laboratory, which was established near London, by the British Government, has produced quite a number of scientific instruments of the highest value. One of these was recently shown at a scientific exhibition in London. Its purpose is to render a rotating object continuously visible, while it appears to be at rest. The method adopted is different from that of illuminating the object by a series of brief flashes of light. The principle made use of is a property of reflection from a smooth surface, which is rotated round an axis parallel to the surface, and in line with the axis of the object. When this reflecting surface is rotated at half the speed of the object itself, the image in the reflecting surface appears stationary. This instrument is expected to prove useful for measuring speed and for studying the phenomena of vibration and strain in rotating objects.

Mining Manganese in India

A brief review of the Manganese Industry showing the special value of the Indian deposits.

BEFORE the war the largest supplies of Manganese ore came from Russia and India, but in the last few years, there have been discovered other sources in Brazil, the Gold Coast of Africa, and a few other places. But in spite of the competition of the new fields there is little doubt the manganese industry in the first two countries will continue to develop as the demand for manganese increases. The Indian fields have proved most useful, and the reports all go to show that the prospects for the future are very good. The Indian ore, on account of its hard lump form, is much more suitable for blast furnaces than the more friable ores obtained from the Caucasus, and it is also possible, owing to the better selection, to export a more uniform quality than that which characterises the Russian shipments. The ore consists mainly of psilomelane with an important amount of braunite. The quality of the manganese varies in different fields in India, but on the whole the quality is considered high. The ores of the Vizigapatam district are mainly psilomelane with small amounts of pyrolusite and braunite; the typical ores of the Central Provinces consists of mixtures of braunites and psilomelane; the ores in Mysore are usually associated with banded ferruginous quartzites. The ores from the Central Provinces are considered of the highest grade, while those from Vizagapatam and Mysore belong mainly to the second and third grades. The first grade ores have a high manganese content, usually from 49 to 54 per cent., and a moderately high iron, from 4 to 8 per cent. The silica varies from 6 to 9 per cent. and the phosphorus about 0.07 to 0.14 per cent. The second and third grades are characterised by high iron and phosphorus contents and comparatively low silica. Though a good deal of prospecting has been done there are no new fields of any size discovered in other parts of India, though it is yet too early to say what a more complete survey will discover. At present practically all the ore mined in India is shipped to Europe and America for conversion, only a few thousand tons being used in India, and this chiefly as a desulphuriser in iron and steel furnaces. With the development of the iron and steel industry in India, doubtless a larger demand will be made on the supplies, but for many years to come India will need to seeks its markets in the West. Unfortunately the high percentage of phosphorus in India ore and coke makes the supply not so satisfactory for Indian use as supplies from other parts. But with the improvements in the iron trade the necessary adjustments would probably be easily made.

Opening up a Manganese Mine

The metallurgical uses of manganese are many but the greatest percentage, say 95 is used in the manufacture of iron and steel. The remainder is used in chemicals, dry batteries, glass and paint industries. It was estimated that in the year 1918, the demand for manganese for the manufacture of dry cells in America, and flint glass was at the rate of 35,000 tons per annum. Unless there are new uses discovered for the use of the ore, it is not likely the output of the Indian mines will greatly increase, but it is very probable the ore will be found increasingly useful in other directions. In a lecture delivered in Calcutta, Mr. L. H. Fermor of the Geological Survey of India, stated that "Of over 1,000 species of minerals known to science about one-eighth contain manganese as an essential constituent, whilst many others contain it in less important quantities. It is calculated that over 10 per cent. of the earth's crust carries manganese peroxide, manganese being ranked as the fifteenth most important element in that respect. As a result of the decomposition and denudation of the surface of the earth, effected by rain and other agencies, its constituents are carried either in suspension, or in solution to the sea, and it has been estimated that every year about 37,000,000 tons of manganese compound containing nearly 26,000,000 tons of manganese are carried in solution in river water to the sea."

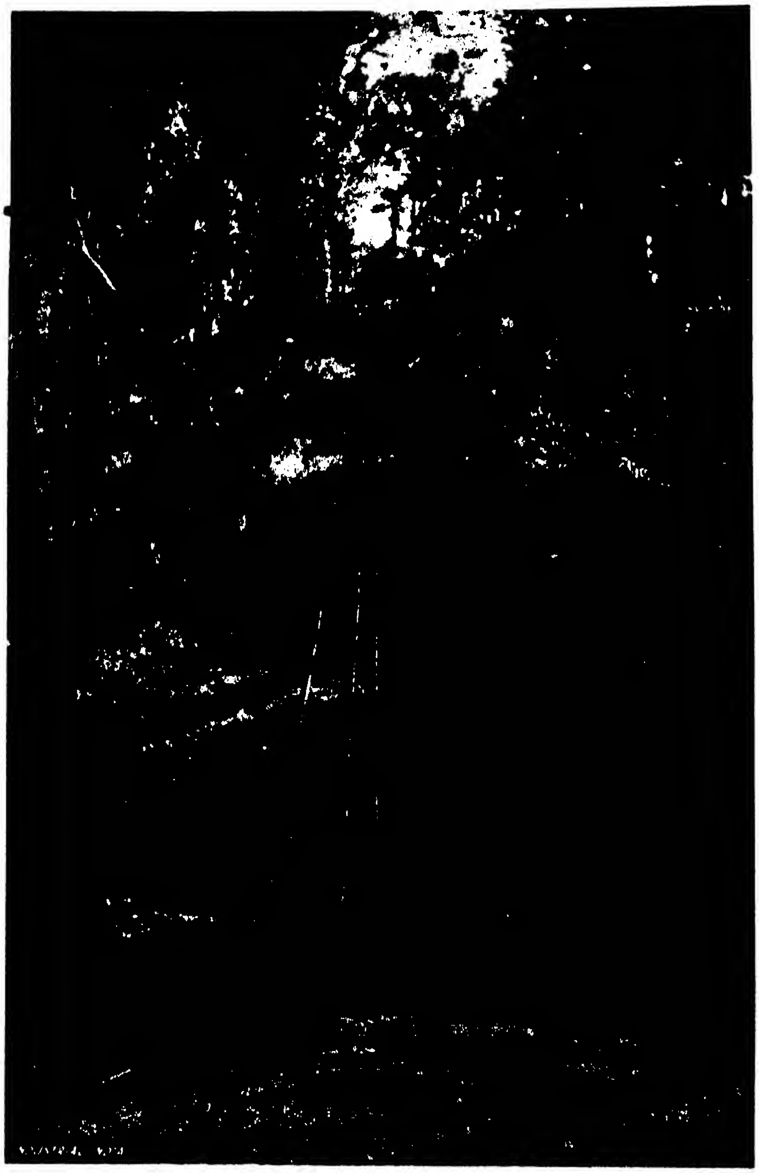
Some years ago the manufacture of ferro-manganese was begun in India in the works at Jamshedpur, and the alloy produced was of the following composition. Manganese 70 per cent., phosphorus 0.55 per cent., and silicon 2 to 3 per cent. The output from one furnace reaches about 80 tons a day. Ferro-manganese is also manufactured by the Bengal Iron and Steel Company, the product having a guaranteed minimum of 74 per cent. manganese, and a maximum of 0.55 per cent. phosphorus. It is believed that with a careful selection of the Indian ores, some real advance may be shown, though it has been pointed out new methods will need to be adopted in the blast furnace if India is ever to become eminent as a maker of ferro-manganese. The possibilities of electric agency will have to be carefully considered.

A Tramway in the Jungle for conveying Manganese

In recent years the manganese deposits in the Mysore State have been extensively worked, mainly by the firm which was known as the Workington Steel and Iron Company. Many prospectors staked out claims and a certain amount of work has been done in several other districts other than Shimoga, but for the most parts these have not proved very successful. There are deposits in the Kadur, Chitaldrug and Tumkur districts as well, but the conditions do not seem very favourable to active mining operations. In the year 1908, the company above referred to took over the area in which they are working and it has carefully developed the area on scientific lines. The work has steadily progressed, and from this mine large quantities have been sent to England to supply the needs of the great iron and steel works connected with them. From the beginning the work has been under the control of one manager, who has been able to follow his plan of campaign from the beginning. The town of Shimoga was selected as the headquarters of the developments, as this place was on the railway line, and presented facilities for the dispatch of the ore. In this town all arrangements for the work were made. A large workshop for the necessary repair of the engines was erected; land was purchased near the railway for the storing of the ore, provision was made for the education of the employees, who might be brought from other parts of the State, and South India, for work on the mines. A well equipped dispensary, and also a laboratory for the testing of the manganese ore brought from the mines. In charge of this work is Captain C. R. Valentine, to whom the writer is indebted for some of the details of this article. It is under his skilful guidance that the work has been carried out, and he is mainly responsible for the many developments that have taken place since the formation of the company. He knows every inch of the ground in the district, and his investigations have resulted in opening up several valuable areas. Evidence of his keen interest in the welfare of the men may be seen in the provision he has made for their recreation, housing, schooling, etc., all of which are a great asset to the work. The Engineering Department is in charge of a trained engineer, who is responsible for the important work connected with this branch of the Company. Not only has he to lay railway lines through the rough hilly country, set up everything necessary for bringing the ore to the railway station, but he has to keep in good condition the engines required for this purpose. A visitor to the workshop here will be not a little surprised at the various kinds of engineering work done. These men are seconded in their work by several other Europeans, who have charge of the separate manganese fields, and by subordinates on the line. The ores brought from the mines are all carefully tested by a man who has been trained for the work, and then carefully graded. All the grades are clearly marked off in the large hills of manangnese near the railway line, so that it is possible for the manager to calculate very easily the value of a particular heap of mineral. In supplying the market, the Company must be able to state definitely the amount of mananese in the ore, and as this varies very considerably such a classification is absolutely essential. In some heaps the ore is of the greatest value almost "worth its weight in gold," and this naturally brings a very high price in the market. The grade of the Shimoga ore is very good and brings a good price at home.

The Mining Areas

The mining areas are known as Kumsi and Shankargudda. The former is situated north of the small village of Kumsi, about 3½ miles distant. The ore is found *in situ* on the northern slopes of a subsidary rise, which is practically parallel to the higher and main hills of the locality. The geology of this section of this country is rather obscure owing to the very heavy undergrowth and subsoil. But from the indications observable it would appear as if ferruginous quartzites and dolomitic limestones were the main rocks with minor mases of quartz and quartzite rocks. The general strike of the ore runs are east of north by west of south. The situ ore runs consists of series of parallel bands or lenses covering a distance of between 2,000 and 3,000 feet in length, and a total width of about four hundred and



The Tramway from the Mines to Rail

fifty feet. The ground between the lenses is almost barren of true ore, and consists of residual clays and ferruginous soils with isolated boulders of manganese scattered through it. The ore lenses themselves are, in the main made up of a ferruginous soil mixed with a black manganese impregnated soil in which the ore masses have grown *in situ* with the formation first of wad (a peaty like peroxide of manganese dark in colour) and later of psilomelane (a very hard crystaline mineral with sometimes a bright fracture). Towards the eastern ends of the property a very large quantity of pyrolusite, both hard and soft varieties, has been excavated and transhipped to England. The system of mining resembles the underground long wall principle with this difference, that there is no over-head roofing or gallery work. There is a series of low wall terraces which are cut into the ore lenses which run the length of the hill. Convenient tramways, two feet guage, are laid, for the running of hand pushed tipping trucks, so as to facilitate the getting away of the ores to the inclines, or on the lower workings direct to the main line trucks. The manganese is also taken to the dumps. The existing inclines are on the gravity principle, a loaded carrier pulling up an empty one. This property is linked up with the depot at Shimoga, a distance of 28 miles, by means of a well constructed two-feet guage railway. The average gradient of this line is one in 80, and is almost entirely in favour of the load. This tramway has also been very largely used by the Mysore Government, who have brought down large consignments of timber from their forests, and have also used it for the conveying of iron ore to the new Iron Works at Bhadravati. There is a second block, known as Shankergudda, which is being developed. As a rule the ore is not mined to any great depth. In the Mysore area it seldom goes below fifty feet, and in most parts even this depth is not reached. The Government of Mysore has in recent years adopted a policy of careful control over all licenses for prospecting and developing the mineral resouces of the State, in the belief that the mineral wealth of the State should be reserved for the State. They perhaps do not realise that minerals are not much use unless they can be put on the market, and it would be a short sighted policy to hinder any such developments as have taken place in the Shimoga section, and which has brought in a fair addition to the State revenues, as well as found employment for a large number of subjects of the State.

A NEW MOWING MACHINE

The standard type of machine for mowing grass consists of a revolving cutter, operating on a stationary horizontal blade. This type of machine is by no means perfect, as it does not cut very close to the ground, and is also ineffective on very long grass. A British firm has introduced a new type which appears to be a great advance on any earlier form. The cutter of the machine consists essentially of two sickle blades, the sharp edges of which are brought together. The movement is such that the knives are practically self-sharpening, and the machine removes any kind of grass extremely close to the ground. Blades of this type can rapidly be attached to any mower, binder, or reaper.

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THE second issue of the *Safety News and Chronicle* contains, among others, a very interesting article on the mine rescue work carried out at the front during the war, which should prove helpful in organising similar work in commercial mines.

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

Air Filtration for Industrial Purposes

THE subject of air filtration in many industries has to-day become one of great importance, not only for the purpose of keeping the factory atmosphere clean, but also for the recovery of the particular dust suspended in the atmosphere.

It is somewhat surprising the number of different classes of manufacturers now dealing with this important subject, such as cement works, chemical works, carpet cleaning works, collieries, flour mills, textile works, porcelain factories, briquetting works, etc.

Legislation has helped in increasing the use of air filters, particularly where the dust laden atmosphere is liable to dangerous explosions, and also, of course, where such atmosphere creates inefficiency among both the human and mechanical elements of a factory.

The same type of apparatus is also used very extensively for the purpose of cleaning gases, such as the by-product of the blast furnace, which is very heavily laden with dust on leaving the furnace. Such gas is generally used under steam boilers for raising steam, and, alternatively, in the cylinders of large gas engines, and it is very necessary, before such gas is used, particularly in the latter case, that it should be freed from all dust.

There are several methods at present on the market for extracting dust from the atmosphere, which we propose to deal with in detail in a later issue.

In this introductory article we propose to describe some typical dry method plants in which fabric bags are used as the medium for filtration, and in subsequent articles to deal in similar manner with the process developed by different firms.

The first apparatus we will consider has been developed by Messrs. A. E. Harris, of London.

The Patent filter dust collector consists mainly of a wooden or steel casing divided into compartments. Each compartment contains a number of filter tubes which are open at their lower ends and fixed to the bottom of the casing. The upper ends are closed by iron covers and suspended from a lever connected to the mechanism. The tubes are made of filter cloth, and the accumulated dust is removed in a simple but most efficient manner by the mechanism, and reversed air currents which automatically act on the tubes of one compartment at a time at certain intervals.

The working process of the machine is as follows:—The suction produced in the filter-casing by a fan, connected to filter by means of piping, draws the dust-laden air into tubes. As shown in Fig. 1, the air passes through the tubes in the direction of arrows and is discharged into the open in a purified state, while the dust is retained in the tubes.

The cleansing of the tubes takes place in the following manner:—A valve in the suction box at the top of each compartment is reversed by the mechanism, thereby cutting off the suction from one compartment, and opening a passage, giving free access to the atmospheric air, which is drawn into the compartment. (Figs. 2 and 3.) This reversed current passes through the tubes from the outside, as indicated by arrows (Fig. 3), and passes out of their lower ends into a neighbouring compartment. At the same time, the tubes are subjected to a thorough mechanical shaking, which, together with the reversed current, frees the dust from the walls of the tubes and allows it to fall into the hopper below, from which it is discharged automatically.

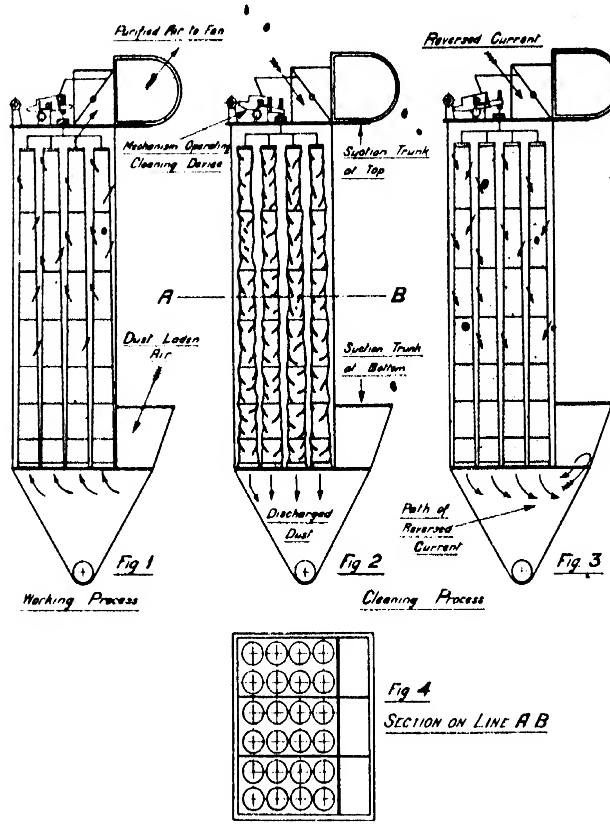
Dust Recovery in a Textile Mill *Albert E. Harris*

The discharged dust passes through an air-lock out of the machine, either to be fed automatically into sacks or to pass to other processes. The shaking of the tubes is repeated several times in rapid succession.

The above-described mechanical process allows of a thorough cleansing of the tubes, so that they have always regained their full filtering capacity when they are brought back to normal work. The cleansing of the tubes of each compartment takes place at intervals of a few minutes, and the disengaging of one compartment during the cleansing process never causes an interruption of the suction at the sources of the dust.

The effect of the cleansing process is increased by the patented conical shape of the tubes, which offers no obstacle to the falling dust. During the usual working process, the conical shape of the tubes has the further great advantage that the free air between the tubes increases upward in proportion to the quantity of the purified air, and that thereby the friction on the casing and the tubes is considerably decreased.

When exhausting dust which contains no poisonous fumes, it is possible to cleanse the air so perfectly that it can be returned into the workshops, thereby having the important advantage in winter of saving the heat of the air.



Sections through Harris Filter

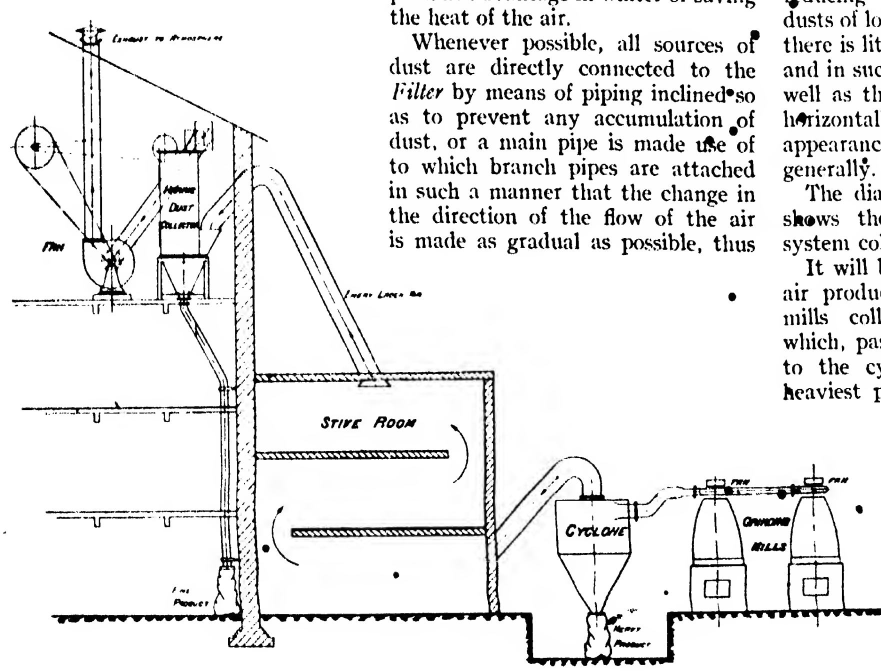
Whenever possible, all sources of dust are directly connected to the *Filter* by means of piping inclined so as to prevent any accumulation of dust, or a main pipe is made use of to which branch pipes are attached in such a manner that the change in the direction of the flow of the air is made as gradual as possible, thus reducing frictional losses. With dusts of low specific gravity, however, there is little danger of accumulation, and in such cases the branch pipes as well as the main pipes are arranged horizontally, presenting a better appearance and reducing costs generally.

The diagrammatic sketch (Fig. 5) shows the working of the Harris system collector in an emery works.

It will be seen that the current of air produced by the fans over the mills collects all floating matter, which, passing through the trunking to the cyclone, there deposits the heaviest particles, which are sacked off as dropped.

The lighter particles passing through the cyclone to the stive-room, or separating chamber, are then again separated into two or three grades, the heaviest particles falling on to the floor.

The emery collected in the stive-room or separating chamber is collected periodically, or conveyed automatically away to the packing department.



—FILTER DUST COLLECTING PLANT IN EMERY WORKS—

—HARRIS SYSTEM—

Passing through the trunking from the stive-room, the air laden with the lighter particles passes through the collector. In the collector the air is thoroughly filtered, the filter sleeves being automatically shaken free of all dust, which is mechanically conveyed to the packing department.

The modern flour mill is to-day relatively dustless, and explosions are scarcely heard of where an efficient system of dust collection is installed. Various attempts have been made to deal with the dust problem, the first of which was the introduction of the stive-rooms. Then followed cyclones, which reduced the explosion risk of the stive-rooms, but they, like the stive-rooms, collected the dust only to deposit it on the neighbouring roofs.

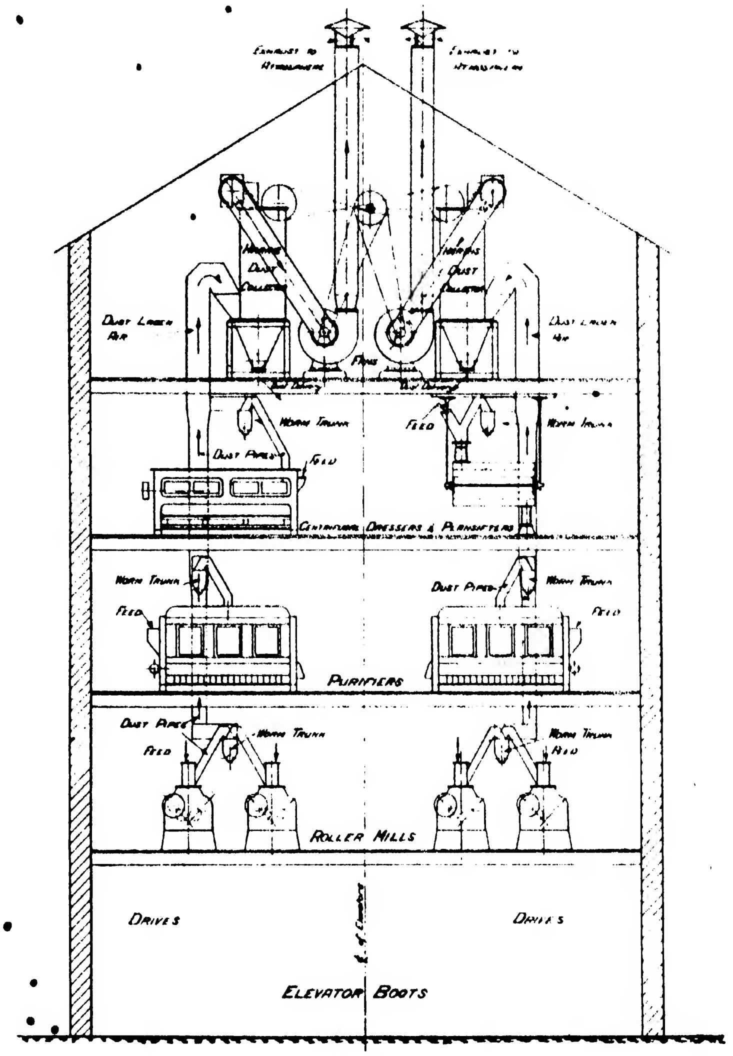
In many cases to-day the system of dust collection draws the dust by an exhaust fan through trunking into a collecting device. This method, however, is not efficient in avoiding explosions, for in a number of disastrous cases the origin has been traced to the exhaust fan.

Flour mill dust is almost pure carbohydrate, which, if in sufficiently fine form and in contact with free air, forms an explosive mixture. If a spark is supplied to this mixture, as may occur through a faulty fan, an explosion may result.

The Harris system avoids this problem by placing the filter between the dust supply and the fan, therefore the air passing through the fan is inert. Besides eliminating the explosion hazards, this system places all the machines in the mill under a partial vacuum, and provides for fresh-air inlets to the machines. This leads to greater efficiency of the machines due to lower temperature and absence of dust in the room. Finally, the dust which used to be scattered over the neighbourhood is collected, and the value of the dust is claimed to be sufficient to pay for the dust collecting installation within a few months.

Considering now the process of cleaning blast furnace gas for use under steam boilers or in gas engines, what is known as the Halberg-Beth system has been very largely adopted for this work.

For a number of years it has been generally recognised by blast furnace engineers that the use of the blast furnace gas in its dust-laden state is very uneconomical. Even in the days of cheap fuel and labour, it had come to be considered a paying proposition to instal a gas cleaning plant, and the recent great increase in prices has only



-HARRIS' SYSTEM OF DUST COLLECTING-

IN

-FLOUR MILL-

served to strengthen this opinion, whilst the present need of increased production provides another argument in favour of adopting every means of increasing the efficiency and capacity of existing plants. That these increases are secured by the installation of a gas cleaning plant will be realised when the following advantages, generally admitted to result from the use of clean gas, are considered :—

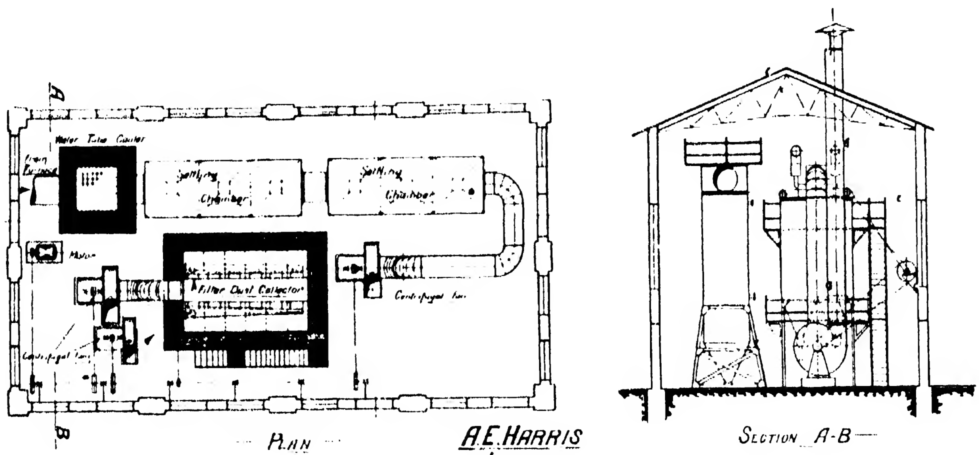
Increased Efficiency of Combustion

resulting in :

(1) Higher blast temperatures from existing stoves, or a reduction in tl number of stoves required per furnac

(2) An increase in the capacity the existing boiler range.

(3) A reduction in the demand f gas from the existing plant, setti free for other uses a considerable pr portion of the gas supply, often mo than 30% of the whole. This spa gas can be used for the production power, either by means of steam gas engines, or it can be used f drying cores and moulds in the ir foundry, for billet heating furna and soaking pits in the steelworks, mixed with varying proportions producer or coke-oven gas, for op



—Installation of Zinc Oxide Recovery Plant—

hearth furnaces, steel mixers, and other processes requiring a very high temperature. For these latter purposes it has been found that one part of producer gas mixed with from one to two parts of cleaned blast furnace gas, gives excellent results.

By suitably arranged crude gas mains, the shutting down of the whole plant for flue cleaning can be altogether avoided. The labour costs of boiler cleaning are much reduced, as only the water side becomes dirty, whilst those for stove cleaning are avoided altogether.

Not only can the stoves be run at a higher temperature, but the elimination of the alkalies contained in the dust prevents fusion of the fire brick surfaces, and thus increases the life of the brickwork from two to four times. With fire brick at its present price this is an important saving, and has been estimated at more than £1,000 per annum per furnace. The same consideration applies with equal force to the boiler settings.

It should be remarked that this considerable advantage is only secured when the gas is cleaned to a high state of purity, and supplied for combustion in a dry state and at constant pressure and temperature. These conditions are eminently satisfied by the Halberg-Beth dry cleaning process.

It has been discovered that by making suitable arrangements, the bulk of the potash contained in the furnace burdens, instead of being lost in the slag, can be made to leave the furnace as fine dust in the gas, whence it may be recovered by installing a gas cleaning plant. With processes depending on gas washing, the large quantities of water to be dealt with, and the insoluble matter contained therein, make this recovery a difficult and expensive proposition. The Halberg-Beth process removes the dust in a perfectly dry state, and the recovery of the potash becomes a simple matter.

Filter Plant working on Emery Dust

Description of the System

Briefly described, the Halberg-Beth system of cleaning blast furnace gas is as follows :

The hot crude gas from the furnace dust catcher, after being sufficiently cooled in the precooler, passes by way of the preheater and dust chamber

to the filter compartment. It is drawn through the filter bags and suction mains by the main fan, and leaves the plant by the delivery main, clean and at suitable pressure.

The dust retained on the inside of the bags is removed periodically by the shaking gear acting in conjunction with a reversed current of hot clean gas which is supplied by the counter-blast fan and reheater, and controlled by a change-over valve operated by the shaking mechanism.

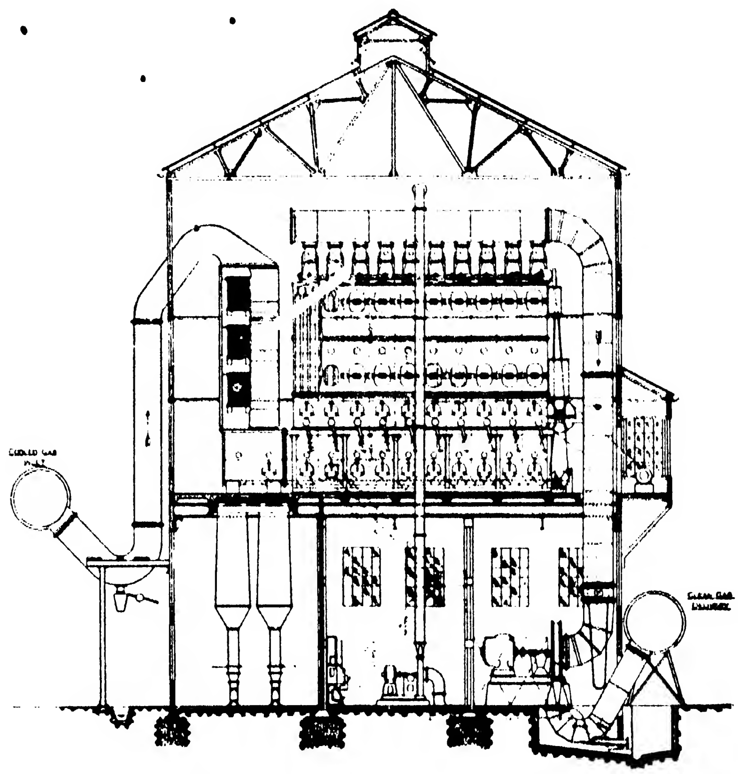
The dust falls into the dust chamber, whence it is removed continuously by a screw conveyor and discharged into dust hoppers arranged to be emptied into trucks by gravity.

Gas to be used in gas engines passes through a final cooler and dryer, before being delivered to the power station.

The function of the preheater is merely to render impossible the deposition of moisture on the filter bags when wet gas is being dealt with, and it may be dispensed with when the moisture content of the gas is invariably low.

Filter units of two standard types are made ; a large one of a capacity of one million cubic feet of gas per hour, and a smaller one the size of which can be varied to suit requirements. The latter is adopted when the gas cleaning plant is merely an auxiliary to a gas engine power station of, say, from 1,500 to 7,000 h.p., the larger units being installed in the case of larger stations and in installations in which, for the sake of the economies thereby effected, the whole of the output of gas is thoroughly cleaned.

It must be allowed that the most thermally efficient use of blast furnace gas for power production is in internal combustion engines, and it is only their liability to break down which has caused preference to be given in the past to steam driven prime movers.

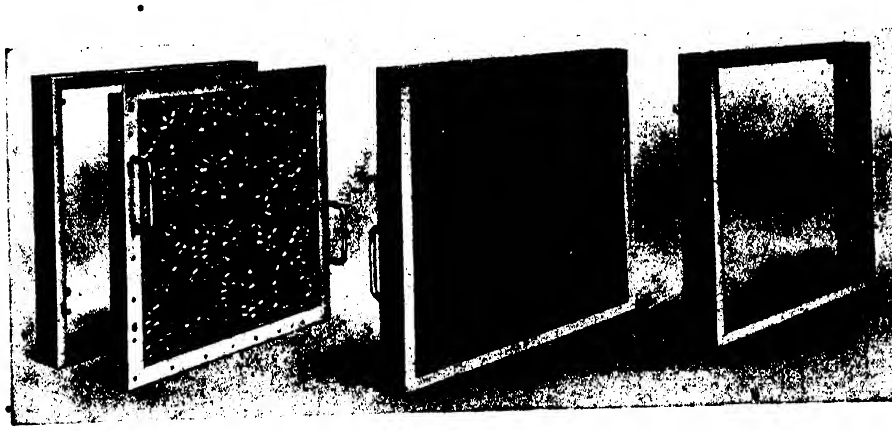


The Halberg-Beth System — *The General Electric Co. Ltd.*

There are, however, gas engine driven power stations at iron works in England which have proved that, provided sufficient attention is given to the gas cleanliness, gas engines can be as reliable as steam engines and run for twelve months or more without overhauling or repair. This result has been obtained by installing the Halberg-Beth gas cleaning plant, which reduces the dust content of the gas to .001 grammes per cubic metre and thus obviates all troubles due to the deposition of dust on working surfaces.

A new departure in air filters is that of Messrs. The Visco Engineering Co. Ltd., London, wherein the filtering medium consists of a very large number of thin coppered steel rings, which are kept coated with a special oil. The dust, etc., suspended in the air, clinging to the oiled surface as the air passes through the filter.

The Visco air filter is made in standard sections of about 20 in. by 20 in. square. Each section consists of the frame and the cell.



Visco Air Filter Dismantled — *The Visco Engineering Co. Ltd.*

The frame is made of steel with welded edges about 3 in. wide. The four sides and the louvred back of the filter cell itself are stamped out of sheet metal in one operation. The edges are welded and the front (the air inlet) is covered with expanded metal. Each cell has two handles, and is simply hooked to the outer frame.

The inner space of each cell is filled with innumerable short rings of very thin coppered steel tubing of small diameter. These rings are covered with "Viscinol," an oil with a very high flash point, non-inflammable, and non-evaporating. It is unaffected by frost or heat, and therefore renders the filter independent of atmospheric influences. Viscinol has an extraordinary covering capacity and adhesion, so that even after months of use it still effectively catches and retains the impurities. Dust of all kinds has a great affinity to "Viscinol."

The "Viscinol" covered rings form the filtering medium. They are filled into the cell through an opening provided in the top, and lie quite irregularly. They offer a very large surface (1 cu. ft. contents equal about 300 sq. ft) to the air passing through, and by their irregular position cause the air to be deviated from its course a great number of times without offering any undue resistance.

The resistance rises from about 4 m/m W.G. when new to about 8 m/m W.G. when at work. Moisture adheres to the filtering medium. The humidity of the air is reduced.

The filtering efficiency of the Visco air filter has been ascertained by many practical tests. These have shown an efficiency of at least 97%, and in many instances a great deal more. The Visco air filter requires a very small space, and can be fitted into almost any position.

Low Temperature Carbonisation (v)

By DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min.E., Mem. Am. Soc. M.E., A.I.Mech.E., etc.

In this, the fifth of our series of articles on Low Temperature Carbonisation, Mr. Brownlie deals with the process developed from Mr. Harold Nielsen's invention

THE "L. M. N." process is owned and controlled by Messrs. Bryan Laing, F. D. Marshall, and Harald Nielsen, of 100 Victoria Street, Westminster, London, S.W.1., and is based on the original invention of Mr. Harald Nielsen, a Danish engineer resident in this country.

The process consists in the use of a long slowly revolving slightly inclined retort or kiln, somewhat on the lines of a cement or ore roasting kiln, in which the raw coal is fed in continuously at one end, and emerges as low temperature fuel at the other. The heating is carried out internally in the most ingenious manner, using the sensible heat only of producer gas (or other inert gas), which traverses the interior of the revolving retort in the opposite direction to the travel of the coal. The cooled gas, after passing out of the retort, is then available for burning or for use in gas engines in the ordinary way, and has also been enriched by the valuable gas given off by the carbonisation of the coal. Thus the temperature of the gas from a hot producer plant is about 1562 deg.-1742 deg. F. (850-950 deg. C.), from a semi-cold plant 1202-1562 deg. F. (650-850 deg. C.), and in the case of a cold plant with by-product recovery 1022 deg.-1202 deg. F. (550-650 deg. C.), so that a fair average figure for the temperature of producer gas can be taken as 1382 deg. F. (750 deg. C.). When producer gas is reduced in temperature by external cooling to recover the by-products, chiefly sulphate of ammonia, there is a very serious loss in efficiency, the sensible heat thrown away in the cooling medium being equivalent to 14-18 per cent. of the original heat in the coal. The "Nielsen" process is therefore essentially a combination of a producer plant and a low temperature retort, so that the sensible heat of the producer gas, instead of being wasted, is used in carbonising the coal.

Another point raised by Mr. Nielsen when designing his retort was that of the speed of carbonisation, and his contention is that, with proper methods, practically all the carbonisation is completed in the first three hours, and there is no practical object to be gained in prolonging the time.

A very interesting series of curves given by Mr. Nielsen, shows the amounts of methane, hydrogen, heavy hydrocarbons, and carbon monoxide given off during the first four hours of low temperature carbonisation at 1110 deg. F. (593 deg. C.) The bulk of the most valuable of the volatile constituents (carbon monoxide, methane, and heavy hydrocarbons) are given off during the first two hours, the yield gradually falling as the time extends, whilst the hydrogen yield on the other hand increases. The hydrogen curve cuts the carbon monoxide curve after about 2½ hours, and the period of carbonisation of 2½ hours is the "Nielsen" process is based on this fact. That is to say, the bulk of the valuable products have come off by this time and there is no commercial advantage in carrying the carbonisation further.

The gas falls off in specific gravity very fast between the first and third hour of carbonisation, because of the hyrdogen increase, and the heating

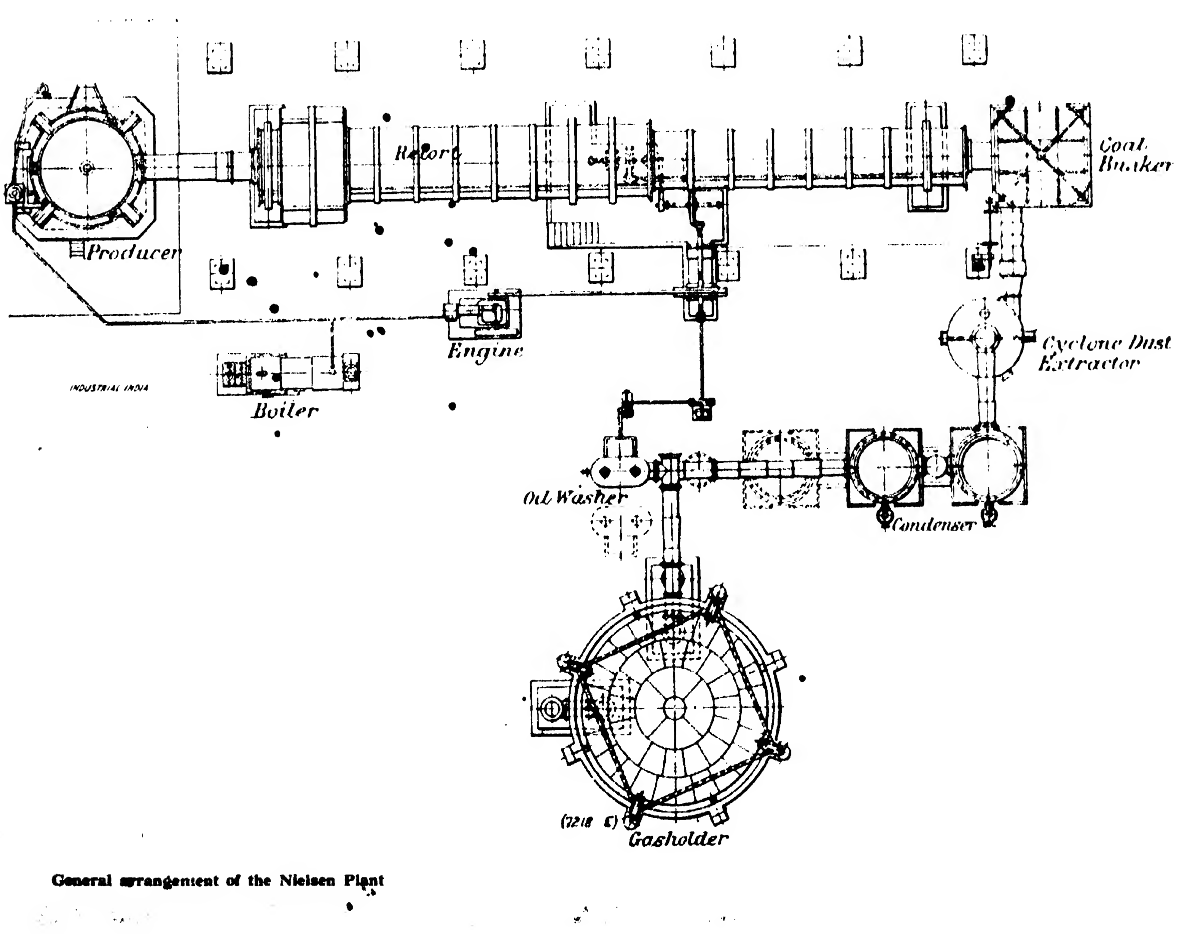
value of the gas diminishes practically to the same extent as the specific gravity.

Mr. Nielsen also contends that the internally heated retort is superior to the externally heated type, and that the yield of gaseous and volatile products rises much more quickly to a maximum, and falls more abruptly in the internally heated as compared with externally heated, 75/80 per cent. of the total yield of low temperature gas is given off during the first $2\frac{3}{4}$ hours, with internally heated retorts, whereas with external heating the figure is 70-75 per cent. Another advantage claimed for internal heating is the great increase in the efficiency of the process. Thus, from a theoretical point of view, the amount of coal required for carbonisation at low temperatures is not more than say $2\frac{1}{2}$ per cent-$2\frac{3}{4}$ per cent. of the total weight, with coal of say 3-4 per cent. moisture content. In practice 10/15 per cent. of the coal is used in the case of the ordinary externally heated retorts, even with the most modern arrangement of preheating and regeneration, whereas in the "Nielsen" process, because of the intimate contact between the coal and the heating gases, the figure is claimed to be only 6-8 per cent. of the weight of the coal, less than half the ordinary figure.

Another point is the bad heat conductivity of coal, so that in the case of the ordinary stationary retorts it is only possible to carbonise the coal in thin layers not over 3-4 in. thick, whilst the time of carbonisation must be 6-8 hours to complete the process right to the centre of the coal. Mr. Nielsen is of the opinion that even under these circumstances the carbonisation is unequal. Thus he states a layer only 3 in. thick, gives a low temperature fuel varying from $10\frac{1}{2}$ per cent. volatile matter on one side of the layer to $13\frac{1}{2}$ per cent. on the other, and the only way to get quick and even carbonisation under these circumstances would be to use layers of coal not over $1\frac{1}{2}$-2 ins. thick, which is not, of course, a practical proposition because of the small output.

It is claimed that the "Nielsen" continuous rotary retort gets over all these difficulties. The time of carbonisation is only about $2\frac{1}{4}$ hours, and 6 8 per cent. of the coal is used in the heating, the process is continuous, the labour and attendance is reduced to a minimum, the radiation losses from the plant are extremely small, the amount of coal handled is very large, and can be several hundred tons of coal per retort per 24 hours, the coal is in continual motion as it is continuously carbonised in gradually increasing zones of temperature, and by this means the bad heat conductivity of the coal is overcome to such an extent that pieces of coal up to 3 in. cube are thoroughly and uniformly carbonised, so that the volatile content does not vary 1 per cent. in any portion of the small lumps of residual low temperature fuel.

An experimental plant has been running for a number of years at the Chatterley-Whitfield Collieries, near Stoke-on-Trent, but a better idea of the "Nielsen" plant will be obtained by giving a description of a very large retort with a capacity of 100 tons of coal per 24 hours that is now



General arrangement of the Nielsen Plant

being erected in India, for Messrs. The Carbon Products Co., the general details of which are shown in the two illustrations.

Rotary Retort

The long inclined rotary retort is 90 feet long, varying from 7 ft. to 9 ft. diameter, the larger end being at the lowest or discharge point. Raw coal, broken to the size already mentioned, and washed if thought necessary, is fed in from an overhead coal bunker, and the hot gas from the producer, averaging 1382 deg. F (750 deg. C.), but, as previously pointed out, varying in temperature according to the method of production, enters the retort at the lower end on the contra-flow principle, and travels through in the reverse direction to the travel of the coal. The gas then emerges at about 248-482 deg. F. (120-250 deg. C.), from the upper end of the retort, and passes through an ordinary by-product recovery plant consisting of a cyclone dust extractor, which removes the dust, and then through condensers, which separate the tar oils, whilst the gas, after extraction of the light oils, passes on to a gasometer, which acts as a pressure equaliser for gas fired boilers. The retort rests on a series of supporting rollers and runner bands, and is driven by means of a small engine, by means of gear wheels through a spur ring surrounding the retort, the speed of revolution of the retort being about 16 revolutions per hour, and the horse power required about 10. Endwise motion of the retort is prevented by thrust rollers working against the side of the runner band. Near the larger end the retort is surrounded by an annular belt, 14 ft. in diameter, for the purpose of discharging the residual low temperature fuel in an inert atmosphere through hand-operated sliding doors.

The interior of the retort is lined with a 9 in. firebrick, and a 3 in. insulating brick, and the outer steel shell is insulated, so that the outside temperature will be only about 104 deg. F. (40 deg. C.) At the entrance of the retort there is a fixed cylindrical portion, 3 ft. 6 in. diameter which carries both the raw coal feeding mechanism and the gas outlet pipe. This stationary cylinder enters the revolving cylinder (the retort proper), and a gas-tight joint is assured by means of cast iron rings working metal to metal only, and it is claimed that the arrangement gives a gas-tight joint at high temperatures in spite of the large diameter.

The coal falls from the overhead hopper into a mechanical measuring device, and is discharged at any required rate into a trough. In the centre of this trough is a screw conveyor driven by the same gearing that drives the measuring device. The trough is nearly 10 ft. long and the coal is caused to travel in it by means of the usual worm paddles. The coal then discharges continuously into the revolving retort, and travels the entire length by gravity and by the revolving motion, the total time of carbonisation being about 2½ hours. The producer used is specially designed to work in conjunction with rotary retorts on the most modern principles, with rotating ash pan, the internal diameter being 10 ft. The labour required for the whole retort installation is very small, being one skilled chemist or engineer, one mechanic and one labourer, and it is claimed that little more would be necessary for a 200 ton a day retort. The thermal efficiency of the whole process is very high, being over 90 per cent.

Reactions in Retort

The reactions that go on in the coal as it traverses the retort at a gradually increasing temperature are a matter of opinion. According to Bornstein, and Mr. Nielsen appears in general to agree with his views, the reactions are at 212-230 deg. F. (100-110 deg. C.), the separation of free water and occluded gases, 230-392 deg. F. (110-200 deg. C.), commencement of driving off combined water, 392-482 deg. F. (200-250 deg. C.), first appearance of oil vapours, 482-572 deg. F. (250-300 deg. C.), most of combined water expelled, 617-752 deg. F. (325-400 deg. C.), distillation commences, 662-752 deg. F. (350-400 deg. C.), first trace of combustible gas evolved, and at 707-788 deg. F. (373-420 deg. C.), rapid evolution of gas. The organic sulphur compounds begin to decompose at 536-572 deg. F. (280-300 deg. C.

Flexibility of Plant

Another advantage claimed for the "Nielsen" process is its great flexibility. Thus, in the neighbourhood of a large town where there is a market for all the products, the plant can be run to produce solid low temperature fuel for sale as a smokeless household fuel, together with the oils and sulphate of ammonia, whilst the gas can be used in the existing household gas mains if water gas is used for carbonising. Also, in a gas works, ordinary producer gas for heating can be replaced by superheated water gas from regenerators, heated by burning a part of the blow gases, since, as already stated, any inert gas (that is free from oxygen) can be used.

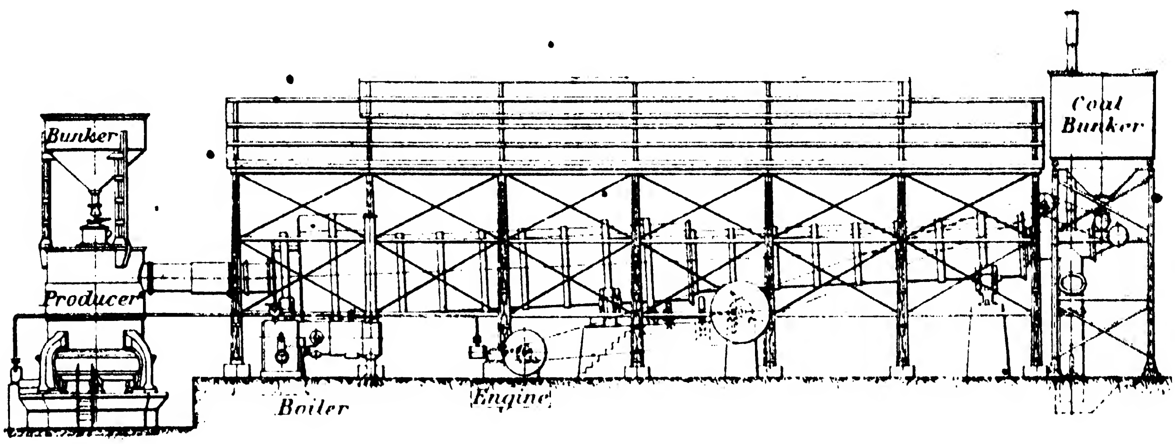
Surplus Gas

If there is no market for the gas, then producer gas is not used continuously. The plant is started up with producer gas and after the first 2 hours' run the producer gas is burnt in reheaters, and the stripped gas from the tail end of the plant is then passed through the reheaters in counter current to the burnt producer gas, and superheated up to the necessary temperature, and then passed through the retort for carbonising the coal. There is in this way a surplus of gas being generated continually, and this can be burnt under boilers to raise steam for the producers and other purposes. Also the residual low temperature fuel can be completely gasified in producers and the gas used either for power generation in gas engines, or for heating, as in the iron and steel industry.

Taking the method of working involving the production of solid smokeless fuel, the yield obtained from 1 ton of coal is given in detail as follows:—In these figures a given average quality of bituminous slack is taken of a heating value of 11,400 B.Th.U. per lb., and an ordinary technical analysis figures of water 2.80 per cent., volatile matter 31.10 per cent. fixed carbon 53.70 per cent., and ash 12.40 per cent. The figures for the ultimate analysis are carbon 68.00 per cent., hydrogen 4.00 per cent., oxygen 9.70 per cent., nitrogen 1.30 per cent., sulphur 1.80 per cent., ash 12.40 per cent., and water 2.80 per cent. The average yield from 1 ton of this coal is:—

(1) 44,000 cubic feet of gas (230 B.TH.U. per cubic foot.)
(2) 20 gallons of oil.
(3) 15/20 lbs. sulphate of ammonia.
(4) 14¾ cwt. residual low temperature fuel.

The gas produced is, of course, a mixture of the rich gas from the carbonisation of the coal, and the unaltered producer gas which has merely been reduced in temperature during carbonisation. The amount of



Elevation of Gas Producer and Neilsen Retort

the rich gas is 4,000 cubic feet, with a calorific value of say 735 B.Th.U. per cubic foot, and the composition is methane 61.6 per cent., hydrogen 17.3 per cent., ethylene 8.0 per cent., carbon dioxide 3.8 per cent., carbon monoxide 4.5 per cent., oxygen 1.0 per cent., and nitrogen 3.8 per cent.

As already stated, the yield of low temperature fuel per ton is 14¾ cwt. (0.735 tons), and if this fuel is used in the producer the amount required is 0.31 tons. This gives a total amount of 39,000 cubic feet of producer gas of 140 B.Th.U. per cubic-foot, and leaves 0.425 tons of low temperature fuel for sale. Of course, any fuel can be used in the producer if there is a good market for the low temperature fuel.

The final gas mixture is therefore 44,000 cubic feet per ton, 230 B.Th.U. per cubic foot, with a composition of carbon monoxide 24.51 per cent., methane 5.45 per cent., hydrogen 13.68 per cent., ethylene 0.38 per cent., carbon dioxide 5.89 per cent., oxygen 0.42 per cent., and nitrogen 49.67 per cent. The 20 gallons of oil produced per ton of coal has a specific gravity of 1.076 at 59 deg. F. (15 deg. C.), as follows: –

Light oils up to 356 deg. F. (180 deg. C.)	4.75%	SG.0.80.
Medium oils from 356-446 deg. F. (180-230 deg. C.)	20.00%	SG.0.87.
Heavy medium oils from 446-518 deg. F. (230-270 deg. C.)	14.50%	SG.0.97.
Heavy oils from 518-608 deg.F. (270-320 deg.C.)	24.00%	SG.1.01.
Pitch	35.00%	
Loss	1.75%	

The crude oil can of course also be used as a fuel oil, and has a heating value of 16,000 B.Th.U. The oil is rich in cressols for wood preservations, and the above fractions contain the equivalent of 20 per cent. of the total volume of the oils (4 gallons per ton of coal), of cressols (soluble in petrols). The free carbon content of the pitch is 0-4½ per cent.

The yield of ammonium sulphate is 15-20 lbs. per ton, but if the producer gas is generated in conjunction with a by-product recovery plant, the total yield is 28-30 lbs.

The low temperature fuel is in the form of small lumps, according to the coking qualities of the coal used, and contains 10-12 per cent. volatile matter, being smokeless and entirely free burning. The technical analysis of the products resulting from the above raw coal shows 70.70 per cent. fixed carbon, 11.50 per cent. volatile matter, 15.90 per cent. ash, and 1.90 per cent. moisture, with a heating value of 11,500 B.Th.U. per lb., with most coals the heating value being slightly higher than the original raw coal.

The balance sheet of the process is given as follows, taking the value of the residual smokeless fuel as only equal to that of raw coal.

COST OF PRODUCTION (1 ton of coal.)

	£	s.	d.
A. 1 ton of coal carbonised 20s per ton	1	0	0
0 313 tons of coal used in producer	0	6	4
B. Labour	0	1	6
Power	0	0	6
Cleaning of gas, water supply, etc.	0	0	9
Maintenance, repairs and depreciation	0	2	0
Total ...	1	11	1

VALUE OF PRODUCTS (1 ton of coal.)

Smokeless fuel (14-15 cwt.) at 20s. per ton	0	15	0
Fuel oil, 20 gallons, say 0.3d per gallon ...	0	5	0
Sulphate of ammonia ...	0	1	6
Power produced from the gas (350 K.W. hours at selling price of 1.0 pence per unit, equals a profit of 0.75 pence per unit)	1	0	7½
Total ...	2	2	1½

This shows a profit of £0 11s. 0½d. per ton (£2 2s. 1½d. £1 11s. 1d.) The smokeless fuel is also very suitable for briquettes, and the cost of briquetting, including the binder, would be 5s. to 6s. per ton, so that if the briquettes were sold at 20s. per ton the profit on the process would then be 5s. to 6s. per ton.

As already stated the "Nielsen" process can be very conveniently used for complete gasification of the coal, but with the recovery of all the valuable liquid products resulting from low temperature carbonisation. If the total gasification is carried out in the improved type of producer plant, the gas produced has a heating value of 152.5 B.Th.U. nett per cubic foot with a composition of carbon monoxide 25.50 per cent., hydrogen 13.50 per cent., methane 2.60 per cent. carbon dioxide 6.00 per cent., oxygen 0.40 per cent., and nitrogen 52.0 per cent, being 42.60 per cent. combustibles. The amount of the producer gas made is 134,400 cubic feet per ton of low temperature fuel.

Finally the "Nielsen" retort is particularly applicable to the carbonisation of shale, and the following results obtained at Chatterley, with a typical Norfolk shale will be of

interest. The analysis of the shale was water 33 per cent, volatile matter 28 per cent., fixed carbon 9 per cent., and ash 30 per cent. It was broken up in pieces about 4–5 inches square, and 1 inch thick, and fed into the retort at the rate of 4 cwt. per hour, along with a shovelful of lime. The speed of the retort was maintained at 15–17 revolutions per hour, depending on the temperature of the producer gas, and the power required was 4 h.p., whilst the pressure maintained in the retort was 1½ in. W.G. The temperature of the producer gas entering the retort was mostly about 1202 deg. F. (650 deg. C.), and this is indicated by the dull red colour of the inlet tuyere, whilst the corresponding outlet temeprature was 410 deg. F. (210 deg. C.). The actual temperature of carbonisation can of course be varied at will, which is one of the great advantages of the "Nielsen" retort. Thus at 1202 deg. F. (650 deg. C.), entering temperature, the spent shale contained only 2½ per cent. volatile matter, but at ay 932 deg.F. (500 deg. C.), corresponding to an exit temperature of 284–356 deg. F. (140–180 deg. C.), the volatile content of the residue was 10 per cent. It is found as a result of exhaustive experiments with the "Nielsen" retort at varying temperatures that it is on the whole better to keep down the temperature or shale carbonisation to about 932 deg. F. (500 deg. C.), and waste 8 per cent. of the volatile matter in the spent residue. At the higher temperature a large amount of objectionable sulphur products is given off, which is not the case at lower temperatures, and each variety of shale must be carbonised at the most suitable temperature, which can easily be found by experiment in the "Nielsen" retort.

The gas evolved, as before, a mixture of unburnt and cooled producer gas, together with the gas evolved from the shale, is about 30,000 cubic feet per ton at 200 B.Th.U. per cubic foot, the gas evolved from the shale alone being 2,500–3,000 cubic feet per ton. The mixed gas is cooled in the condensing plant to 68–71.6 deg. F. (20–22 deg. C.), so as to deposit all the oil product in a liquid form.

The fuel used in the producer as, coke or coal, is about 23 per cent. of the weight of the shale carbonised, but since the producer gas is merely used as an inert heating agent and is ready for burning as usual after the carbonisation, the real amount of fuel used in actually carbonising the shale is only about 8 per cent. The spent shale still contains about 22–25 per cent. of combustible matter, which can be used in gas producers for the production of a further amount of producer gas. The yield of shale oil is about 24 gallons per ton of water free shale, corresponding to 0.86 gallons per ton per 1 per cent. of volatile matter in the raw shale. The oil was of high quality with a S.G. of 0.947.

Improving Traffic Working Methods on Indian Railways

It is an open secret that for a considerable time the Great Indian Peninsula Railway Company has not been at all satisfied with the methods of traffic working on that important line—and, in fact, as we have chronicled in another note, the "operating ratio" has grown to such an alarming extent as to prove the urgent necessity for some drastic change in the prevailing methods. The railway company has been seized with the importance of taking immediate steps to remedy matters, and following a detailed investigation into every phase of the question, the General Traffic Manager has submitted a voluminous report which, *inter alia*, advocates the formation of a new Transportation Department to unite the "operating functions of the traffic and locomotive departments." The question has been considered from the broadest point of view, and the General Traffic Manager, accompanied by the Locomotive Superintendent, visited Great Britain in order to ascertain the practice there and obtain pointers for the development of their own organisation.

The result is as stated, and from what the Chairman of the Company, Sir Charles Armstrong, said at the last meeting of the Company in London, the project is under the consideration of the Government. There can be little doubt that the new department will be sanctioned, as it will certainly expedite and greatly improve the working of traffic—and if there is one thing that is wanted in India, it is some improvement in traffic working conditions. Sir Charles Armstrong added that the new department would obviate friction in many other directions, and although at first it would add slightly to the permanent charges the additional cost would be more than justified, for traffic would be expedited and a better use be made of rolling stock. The result generally, he felt assured, would be more economical working, and he was confident that Indian trade would reap many benefits from the new departure.

Sir Charles is not over-stating the case in making such claims for the new department. Wherever railway working, *qua* working, has been given into the charge of one department, as it has been on most American lines, in Africa and on some British Railways, considerable improvement has been effected in the general arrangements.

Wireless Underground

Although Wireless Telegraphy has been used so largely on the surface and in the air, very little has hitherto been done to utilise it as a means of communication underground. The possibilities in this direction are illustrated in a very interesing fashion by experiments recently made in a British coal mine. An aerial was set up in an underground region a quarter of a mile distant in every direction from the open. With quite a small apparatus signals were heard from a number of high power transmitting stations, including the large station near Berlin.

Diseased Brickwork

By A. B. SEARLE

(*Technical Advisor on Clays and Clay Products.*)

DOES brickwork suffer from disease in a similar manner to human beings? It is certainly corroded by a canker, which has many of the symptons of a germ-disease, and much brickwork—especially in India—is also subject to a "skin disease," which is equally as disfiguring as those of human beings.

In some cases the defect is confined wholly to the surface of the brickwork; in others it has an internal origin, but in an outward disfigurement, and in still other cases, it is due to a combination of internal and external forces. When the brickwork is covered with plaster, that may also succumb to the same defect, with most unpleasant consequences to all concerned.

What is even more remarkable is the fact that walls which have retained their good appearance for years will suddenly develop a series of discoloured patches without there being any obvious reason for their doing so. Most builders of long standing are well aware of these recurrent attacks of discoloration, but few of them have ever been able to ascertain the cause or to find the cure.

Brickwork Canker

The canker which destroys so many bricks in India shows itself chiefly as a gradual rotting away of the material. Small—or sometimes large—pieces of brickwork become loose, and fall off in flakes. Even parts of a wall which appear to be perfectly sound will break off at the lightest touch of a hammer, thereby showing that it is only a question of chance as to how long they remained in position.

In many instances the bricks used appeared to be good and strong when the brickwork was erected, yet after a time it is not difficult to pick off pieces 2 in. square.

The defect is always at its worst a month or more after the end of the monsoon, *i.e.*, after the bricks have been thoroughly wetted and then dried. In the dry weather which then follows, no further rotting appears.

No single cause will account for all the cases of wall-canker which have been observed, but most of them are due to one of two causes, or even to both acting simultaneously:

(1) Weak, under-burned or irregularly burned bricks are obviously liable to give way under the great variations in temperatures to which their surfaces are subjected. This is, however, a very unusual cause of trouble, as bricks must be of extremely poor quality for them to spall rapidly from this cause. The remedy in this case is, clearly, to use sound, well-burned bricks, which "ring" well when struck together.

Bricks shewing Wall White

(2) Far more serious as a cause of the destruction of brickwork is the use of a mortar made of a very fat or rich lime, with too small a proportion of sand. As lime is dearer and more plastic than sand, many builders consider that they are doing the right thing in using such a mortar, especially as it is smoother and more pleasant to use. Yet such a practice is quite wrong, for a mortar of the composition and nature just mentioned will never harden properly. It may form a hard film on the surface, but all the mortar behind this film forming about 99 per cent. of the whole—will remain in its original state, except that if the weather is favourable it will gradually dry. At any time, if the outer film is removed, the remaining mortar may be scratched with the finger nail.

The lime in such a condition is readily soluble in the water which penetrates from outside the wall into the pores, and the solution which is then formed in the interior of the bricks endeavours to pass outward more rapidly than the pure water can pass inward, and, as a result, osmotic pressure is set up, and may be so intense that the walls of the pores are burst, flakes of bricks are loosened, and may fall off at any time.

The Prevention of Canker

The only means of preventing the development of this canker, which can, otherwise, continue indefinitely, is to arrange that the mortar shall be suitable for the climatic and other conditions to which the brickwork is exposed.

In ordinary buildings, the use of very fat lime should be avoided, or if it must be used (as when no other is available) it should be made lean by the addition of brick—or tile—dust, from which the coarser particles have been sifted. This material is well-known in the East, and was regularly used by the ancient builders, as may readily be ascertained by examination of the mortar in some of the oldest buildings in existence.

The early Romans found a material—trass of volcanic origin which is peculiarly suitable for the purpose, and they used it extensively. When compelled to find a substitute, they employed fine brick—or tile—dust, with almost equally satisfactory results.

The proportion required depends largely on the fatness of the lime, but

with a good fat lime, 3 measures of trass or dust should be used to each 2 measures of lime. When the lime is made into putty, 3 measures of trass or dust to each measure of lime putty is desirable.

The proportion of sand should also be kept fairly high, unless the brickwork is continually under water. For ordinary buildings and dry foundations, a suitable mortar will consist of 2 measures of dry lime, 3 measures of trass or brick-dust, and 8-10 measures of sand. If the buildings are to be subjected to water at regular intervals, such as damp-proof courses, river walls, etc., only 5-6 measures of sand should be employed, whilst, for tanks filled with water, or for brickwork always under water, it will be better to use only 4 measures of sand.

The use of an insufficient quantity of sand, or of too much lime, does not improve the mortar, as is often supposed; on the contrary, it is one of the commonest causes of wall canker.

Lime can only harden by exposure to air, and fat lime is so dense that air cannot penetrate it. Consequently, a mass of lime putty will remain soft for years. The addition of sand makes the lime porous, and so enables the air to penetrate it, thereby causing it to harden and produce a strong mortar.

There is, of course, a limit to the proportion of sand which can be used, but the figures mentioned above are quite conservative. To use less sand than is recommended would incur a risk of wall canker.

Wall White

Another objectionable form of discoloration on brickwork is known as *wall white*. This forms a series of white patches, sometimes stained by adventitious materials, on the surface of the bricks. The interior, on the contrary, may be perfectly uniform in colour. Sometimes this "scum" or "efflorescence" appears very soon after the wall has been erected; at other times months or even years may elapse before it is noticeable.

The chief causes of this defect are:

(*a*) Soluble salts in the bricks.

(*b*) Soluble salts derived from the ground.

(*c*) A condensation product on the bricks when they left the brickyard.

(*d*) Soluble lime from the mortar.

In each case, the white material may be seen under a microscope to consist of minute crystals, which, when scraped carefully off the brick, are (with the possible exception of that referred to in section "C") readily and completely soluble in water. They are often known as "nitre," but have no connection whatever with the substance generally known by that name.

A more detailed examination will show that the chief constituent of the discoloured portions is a mixture of sodium, potassium, calcium and magnesium sulphates, the proportions of each varying within extraordinarily wide limits. These sulphates are all soluble in water, though the calcium sulphate is the least soluble, and all of them crystallise readily when the conditions are favourable.

Discolouring Salts

Such salts may enter the brick in various ways; they may occur in the clay or other material of which the bricks are made, or in the water used to moisten the clay. They are particularly present in ashes which are sometimes used to reduce the plasticity of the clay; indeed, this is much more often a means of introduction than their presence in the clay itself. Sea sand if a firm is so foolish as to mix it with the brick earth, or use it in mortar will also introduce soluble salts and will often, though not always, produce white patches on the bricks.

The discoloration due to soluble salts in the bricks cannot be removed satisfactorily, though by repeated scrubbing much of it may be taken away. Sometimes a little acid in the water used for cleaning the bricks is an advantage. The brick manufacturer may prevent the scum by converting the salts into insoluble ones by the addition of a suitable chemical. Many have been tried, but, so far, there is nothing superior, in this respect, to precipitated barium carbonate or to barium hydrate. The former is a little less risky to use, as the latter in excess—may increase the defect, as it is, in itself, soluble in water. The amount of barium carbonate or hydrate must usually be ascertained by means of a suitable test. This quantity is mixed with sufficient water to form a cream or "solution," which is then thoroughly mixed with the clay before the latter is made into bricks, etc. The soluble sulphate is then converted into an insoluble one, and the latter is unable to reach the surface, and so spoil the bricks. No means has yet been found to prevent soluble chlorides from forming a scum on bricks.

Scum Due to Bad Storage

When bricks are stacked on ashes they will, in wet weather, produce a white scum. The rain-water dissolves some of the salts in the ashes, which rise in solution into the bricks and then flow to the most rapidly drying surface. As the water evaporates, it leaves the salts on the surface of the bricks in the form of patches of white scum.

The only means of preventing this form of wall white is to avoid stacking or building the bricks on ashes.

If a wall is built on a damp foundation, or if liquids are allowed access to the lower part of the brickwork, the white disfigurement will be produced in the same manner as from ashes. Stable manure, when allowed to be against a brick wall, will have the same effect and for the same reason.

Kiln White

Some bricks have the discolouring white patches when they leave the brickyard. These may be "kiln white," which is formed by the action of kiln gases condensing on the bricks during the burning process, particularly in continuous kilns. All coal contains a small proportion of sulphur, which gradually forms sulphuric acid and travels along in the kiln gases. As soon as these gases become cooled by contact with damp, freshly-set bricks, the steam and sulphuric acid in them condense on the bricks. The acid combines with any lime, magnesia, soda or potash compounds in the bricks, forming the corresponding sulphates, which gradually form a white or grey deposit on the surface. The deposit may be coloured if other compounds are present and form coloured soluble salts, or if soot or smoke is deposited on the bricks and is not, afterwards, fully burned off.

This form of discoloration may be prevented in two ways: either the bricks may be heated with air free from sulphuric acid until they are at too high a temperature for any condensation to occur on them, or the last stage of the firing may be effected with a reducing atmosphere, which converts the sulphates into sulphides and so destroys the greater part of the deposit. Unfortunately, the reducing atmosphere may spoil the colour of the bricks, and no final oxidizing atmosphere which is

applicable may be sufficiently powerful to restore the desired colour. The reducing atmosphere can be created in continuous kilns with definite chambers, each partitioned from the others, but with an "open" continuous kiln, such as those used in India, it is much more difficult to do so, and, indeed, is scarcely practicable. Consequently, it is better to prevent condensation by heating the bricks with pure hot air before taking them into the "round of the kiln." This is known as "water-smoking" in distinction from preheating with kiln gases.

Lime White

Occasionally the white patches on a wall are composed solely of lime. This is derived from the mortar, part of which is dissolved by water penetrating the joints and then brought to the surface of the bricks. The lime is then left behind as a residue in patches which may be some distance from their source. The cause is essentially the same as that mentioned in connection with ashes, but originates in mortar which has not hardened. It can be prevented by the use of trass or brick-dust, as previously described.

Yellow and Green Discoloration

Yellow and green discolorations are usually due to vanadium salts, and are comparatively rare, for though the salts are present in minute proportions in many clays there is seldom sufficient to cause a noticeable patch of colour. This form of discoloration is difficult to avoid, though if the bricks are heated in a reducing atmosphere the discoloration may be destroyed.

Removal of Wall White

The removal of the discoloration is best effected by scrubbing with plenty of hot water. A little hydrochloric acid is sometimes added, but is of doubtful value. The use of an alkaline soap dissolved in about a hundred times its weight of hot water has proved successful in some instances. Many mixtures have been proposed as suitable for removing "wall white," and similar efflorescences and some of these mixtures have been patented. Most of them are little or no better than soapy water, but molasses or a dilute solution of sugar have been more highly recommended.

If the white is limited in amount, one or two cleaning treatments may remove it—though always at the risk of spoiling the true surface of the bricks and rendering it less durable. If fat lime in the mortar is the cause of the discoloration, there is no means of removing it, as it will continue to form so long as any soft lime remains in the mortar. The same applies to a foundation impregnated with soluble salts, and to any solutions having frequent or prolonged access to the lower part of the brickwork.

Occasionally, the interposition of a damp-proof course will prevent the formation of wall white by providing an impervious layer, through which the salt solutions cannot penetrate. This remedy only applies when the defect is due to damp foundations.

Finally, when the discoloration is very objectionable and no other means of overcoming it is available, the use of tar, paint, whitewash and stucco may be considered. Tar will make the wall uniformly black, which is very objectionable in a hot climate, as it absorbs the heat rays from the sun. Paint is costly, requires frequent renewal, and does not always adhere well. Whitewash is excellent for many purposes, but its appearance is not always appreciated. Stucco or "rough cast" is an external coating made of Portland cement and sand, which alters the whole appearance of the structure. It is liable to suffer from similar defects to the brickwork, as unless it is made quite waterproof the salts may rise to the surface of the newly applied material.

Satisfactory cures being almost unknown, attention should be concentrated on preventive measures, the chief of which are:

(1) A good damp-proof course, 2 ft. above ground-level, which will confine most of the discoloration to within 2 ft. of the ground.

(2) Avoidance of solutions or of wet saline soil in contact with any part of the brickwork.

(3) The avoidance of too fat a lime in the mortar, unless this is neutralised by a suitable agent such as trass or brick-dust.

(4) Careful selection of the bricks to ensure that they are well-burned, followed by sufficient supervision to prevent their being stacked on ashes or other material likely to damage them.

THE ADVANTAGE OF AERIAL ROPEWAYS

In view of the series of articles on "Aerial Ropeways," that has been published in these columns, it is worthy of record that, at a recent meeting of the Punjab Engineering Congress Capt. and Bt. Major F. H. Budden, M.C., R.E., contributed a most interesting paper on this subject. The author considered the question on a very comprehensive basis, and it is instructive to note that, generally, his final conclusions agreed with those of our Transport contributor. Among the ropeways described by Capt. Budden, were the installations of the 3-cable type, between Crespano and Mt. Grappa in Italy, the Shropshire Mines Ropeway at Minsterley, and the Dorada Ropeway, the last-mentioned of which has been treated at some length in the pages of INDUSTRIAL INDIA. Capt. Budden's paper is reprinted in the *Royal Engineer's Journal* for June, 1922, and is accompanied by an exceedingly clear plate illustrating various types of ropeways and explaining parts of the equipment. In connection with costs, Capt. Budden remarked that there can be no doubt that in favourable circumstances a well-designed ropeway effects a considerable saving in transport costs over other means of transport. This was a point upon which our own contributor laid stress, as it furnishes a strong argument for the consideration of a ropeway installation in difficult country.

Centrifugal Castings

By F. E. HURST

The process of making cylindrical castings by what is now known as the Centrifugal method, is a relatively new departure, but has attained considerable commercial success. Mr. Hurst in his paper before the West of Scotland Iron and Steel Institute, dealt with this subject largely from the point of view of the chemical and physical composition of the iron used, and we reprint the greater part of this very instructive paper.

A CONSIDERABLE amount of interest is attached to the method of the production of castings by the introduction of molten metal into rapidly rotating moulds carried on specially designed machines, a process which has now come to be well known as the Centrifugal Casting Process. It is the author's intention to deal in a somewhat brief manner with certain of the aspects of this process as applied to the production of cast-iron castings.

The process, as at present operated in the works with which the author is connected, is being applied to cast-iron for the purpose of producing large-size castings for piston ring sleeves, gas, oil, and Diesel engine cylinder liners, chilled wheel and chilled roll castings, and cylindrical castings of all descriptions. The machines at present in operation are capable of producing castings up to a maximum length of 36 ins., and of varying diameters from 10 ins. up to 30 ins. Other machines for the production of both smaller and larger-sized castings are at present in course of construction. The principle of operation of the centrifugal casting process consists of the introduction of molten metal into the mould or die which is rapidly rotating about a horizontal axis. For cylindrical articles no core is used, and a perfectly cylindrical interior surface is produced direct by virtue of the centrifugal force under which the metal solidifies and the rate of introduction of the metal into the mould. Castings other than chilled castings are produced at the author's works, directly machinable, a feature which is arrived at by strict control of the chemical composition of the metal and the details of the mould and casting operation.

The machine consists essentially of face-plate mounted on a shaft carried in bearings arranged to be rotated at the required speeds. The moulds are attached to the faceplate by bolts, and when rotating the molten metal is introduced by tilting a specially designed pourer which has been moved into position inside the rotating mould.

Construction of Moulds

The moulds themselves are constructed in two parts viz., an outer holding casting which is arranged to bolt to the faceplate and an inner liner which is arranged to fit loosely inside the holder casting. The liner is bored internally to the size and dimensions of the outer surface of the casting to be produced, and the outside of the liner is bored to fit the holder casting, which is designed to take a group of a series of liners, the dimensions of which are arranged to produce flanged cylindrical castings of a standard series of dimensions. By this means the cost of the renewals of dies for the production of a given size is considerably reduced, and as a rule the series of holders will take most special liners required for the production of castings of special shapes.

The back end of the liner next to the faceplate of the machine is closed by a plate attached to the end of a screwed rod passing through the hollow shaft of the machine and arranged for the ejection of the castings. The front of the liner is closed by an annular plate having the internal diameter of the annular ring corresponding to the internal diameter of the casting to be produced. This plate is arranged to be removable after the completion of the casting operation in order to allow of the extraction of the casting.

As indicated, a series of standard dimensions of flanged cylindrical castings has been drawn up, and the installation of the necessary holders and liners to produce these, makes it possible to produce a wide variety of cylindrical castings within the limits of dimensions mentioned above and with comparatively trifling alterations. For example, the only alteration to the die required to produce castings thicker than a given standard casting is an alteration to the diameter of the inner circle of the closing plate. Castings shorter than the standard range of size can be produced by an alteration in the position of the ejector plate. Castings having specially shaped flanges or external projections require a special liner, but here again, in the majority of cases, a special liner only is required, and the expense is not necessarily prohibitive. Castings having internal projections, or closed cylinders or dish-shaped castings, cannot yet be produced on a commercial basis.

For larger-sized castings than the above mentioned a somewhat different scheme is under installation, but this possesses sufficient flexibility not to place an undue burden on the cost of the castings. This scheme consists essentially of the use of a complete mould or die which on completion of the casting operation is arranged to be removed from the machine along with the casting for stripping purposes. For the production of large numbers of single castings more than one mould would be in progress in order to maintain the sequence of operations. In the case of a casting where the initial cost of more than one die would be prohibitive, it can be arranged to

interpose the single die in series with another die for a different casting, thus still maintaining the sequence of operations. The operation is very similar to the casting and stripping of ingots in an open hearth steel shop.

Chemical Composition of Centrifugal Castings

So far as experience has gone up to the present, it is found that the influence of the various constituents of cast-iron follow the same rules as in the case of sand castings. This is well illustrated by the curves in Fig. 2, indicating a state of affairs and a remedy which has been a common experience in almost every sand-casting foundry. The curves are abstracted from the daily test charts, and show very clearly the increase in the percentage of rejected hard castings as a result of the increase in sulphur content. This was corrected at the time by a slight increase in silicon content. In cases like these there is no doubt that in the centrifugal casting process the castings are more sensitive to the effects of small changes in the chemical composition.

TABLE II

DIRECT TENSILE TESTS ON CENTRIFUGAL IRON CASTINGS

No.	Tot. C. %	Si %	Mn %	S %	P %	Ultimate Strength Tons per sq. in	Remarks.
1	3.21	2.75	0.31	0.11	0.64	17.46	Direct Cupola Melted.
2	2.99	2.70	0.39	0.09	0.64	19.40	Metal from Receiver.
3	2.95	2.85	0.28	0.10	0.92	19.95	,, ,,
4	2.99	1.98	0.35			19.50	Determined on Ring.
5	3.10	2.55	0.29			19.31	,, ,,
6	3.15	2.75	0.29			18.71	,, ,,

TABLE III

CENTRIFUGALLY CAST METAL

		Loss
Original Weight of Specimen	6.7500 grs.	
Weight after 3,000,000 Revs.	6.7349 ,,	0.151 grs.
,, ,, 4,000,000 ,,	6.7339 ,,	.0010 ,,
,, ,, 5,000,000 ,,	6,7335 ,,	.0004 ,,
,, ,, 7,000,000 ,,	6.7331 ,,	.0004 ,,
	Total Loss ...	.0169 ,,

SAND CAST.

		Loss.
Original Weight of Specimen	6.7530 grs	
Weight after 3,000,000 Revs	6.7455 ,,	.0075 grs.
,, ,, 4,000,000	6.7425 ,,	.0030 ,,
,, ,, 5,000,000 ,,	6.7325 ,,	0160 ,,
,, ,, 7,000,000 ,,	6.7220 ,,	0105 ,,
	Total Loss ...	.0310 ,,

Carbon

The advantage of a somewhat lower total carbon content than that of normal foundry irons is well known, and following on this practice it is endeavoured to produce high-grade castings for cylinder and piston ring work in cast-iron with a total carbon content within the range of 2.75 to 3.0 per cent. This is rendered possible by the use of the special melting plant described later.

The combined carbon, on account of the higher silicon content usually worked to, is lower than what is usually obtained in ordinary foundry practice. This is advantageous in castings such as piston rings and the like, which are subject to comparatively high temperature conditions. A series of figures given below, Table I., show that the variations in combined carbon within the limits of the figures given have practically no influence on the tensile strength value. Starting with a cold mould at normal temperature, the first few castings are invariably chilled on the outer surface or the surface next to the metal mould. As the temperature of the mould rises, the chilled surface on the castings rapidly disappears, and the combined carbon gradually reaches a constant value. The figures given in Table I. serve to show the variation in combined carbon with the order of casting. The remarkable feature of this series of figures is that the combined carbon is higher on the inside surface than the outside. This is worthy of recording, and is met with quite frequently. The author has preserved a specimen for future examination of a casting showing a layer approximately one-eight of an inch deep on the outside surface of the casting, which on examination shows no trace of combined carbon. These figures are included with the object of showing the possibility of variation in the combined carbon values. The average value usually maintained is from 0.3 to 0.5 per cent., unless specially desired, when higher values are readily obtained by reduction of the silicon content.

TABLE I.

Sequence No. of Casting	Inside Surface C.C. %	Outside Surface C.C. %
1	0.66	0.47
4	0.49	0.00 trace.
8	0.55	0.10
12	0.17	0.15
16	0.42	0.05
20	0.22	0.15
24	0.24	0.14
28	0.22	0.14

The proportion of graphite present naturally varies with the combined carbon, and in this connection it is of

considerable interest to record that no case has yet been met of any segregation of the graphite during the casting process. This is strong confirmatory evidence that in cast-iron below and up to the eutectic composition the graphite does not form in the liquid state, and is formed quite late in the solidification range. If the contrary were the case, then one would certainly expect to find some indication of the segregation of the graphite to the inner surface of the casting, particularly in view of the wide disparity in the specific gravities of graphite and iron.

Silicon

The average value of the silicon in centrifugal castings is about 2.75 per cent. This is a somewhat higher value than is usually used in sand-casting practice for high-grade work. Lower value than this can be cast.

Sulphur and Manganese

Sulphur existing as the manganese sulphur compound which, as is now known, is insoluble in cast iron at the temperatures usually met with in foundry practice, and is also lower in specific gravity, tends to segregate, under the influence of the centrifugal action, to the inner surface of the casting.

In castings of thinner cross-section the effect of the segregation is much less owing to the increase in rapidity of the solidification. The use of low manganese irons, or increased casting temperature accompanied with rapid pouring, tends to practically eliminate this segregation in all but very thick castings. As a general rule excess of metal is poured into the rotating mould, which is thrown out in castings of comparatively small length and along with it the segregates in the shape of sulphur and slag inclusions which have collected on the inner surface.

Phosphorus

For the successful production of centrifugal castings highly fluid iron is desirable. The well-known effect of phosphorus on this property would appear to be of considerable value in this process. Unfortunately the influence of phosphorus on the properties of centrifugal cast-iron appears to be very undesirable, and in so far as our investigations have gone it is largely to that element that low tenacity and, what is more serious, " brittleness " in centrifugal castings, is to be attributed. This particularly appears to be the case when phosphorus is present in conjunction with fairly high silicon values. For high-grade castings, therefore, on this account only, low phosphorus material is desirable, and a maximum of 0.60 per cent. for special castings is now worked to. This is obtained by the use of steel scrap or hematite, preferably the former, and the necessary fluidity, and incidentally, uniformity, is obtained by maintaining a high casting temperature in the melting plant specially designed for this purpose. Before leaving the question of phosphorus, it is of interest to mention a curious tendency noticed on several occasions for the phosphorus to segregate to the outside surface of the castings. This the author believes is worth recording, as a similar tendency has been noticed in the case of the eutectic in the die casting of copper aluminium alloys.

The composition of some of the different articles recently made on the centrifugal casting machines are included in Table II. These figures are included with the object of giving some idea of the range of composition which can be satisfactorily dealt with by this process.

The cast-iron containing nickel and chromium is being used for the production of the chilled iron wheels previously mentioned and illustrated. The author is yet unable to give data of the physical properties of this material as centrifugally cast, and its use for this purpose has suggested itself on the basis of certain stationary chill casting experiments of which the author has had previous experience. The main object in using this material is the desirability of producing a chill having an extremely close grain, as distinct from the somewhat coarser grain of plain cast-irons. The composition is at present being obtained by melting nickel chrome steel scrap in the mixture.

Physical and Mechanical Properties of Centrifugal Castings

It is necessary to point out that the consideration of the mechanical properties of centrifugal castings should always be made in conjunction with the chemical composition, and this must be taken into consideration when making comparisons between centrifugal and sand castings. So far as the investigation of the properties of centrifugal cast-iron has gone at present, in all cases a distinct improvement in the mechanical properties has been found. An improvement would, of course, be expected on the grounds of the use of a metal mould, although there is no doubt that the centrifugal method itself has considerable influence in modifying the properties of the cast-iron.

The figures given in Table II. are the results of tensile strength determinations on bars and rings cut from centrifugal castings of the compositions given in the table. This collection of results serves to show the influence of the reduction to total carbon content in increasing the tensile strength and the slight falling off in strength with increased silicon content. In all cases it will be agreed that the values are slightly higher than would be obtained from sand castings of identical composition. The tensile test specimens were in all cases machined from the castings, and where the method of determination is stated as direct, the test piece was machined up in the ordinary form and broken in the usual manner. In those cases where the determination was made on rings, the procedure recommended in British Engineering Standards Specification, 2 K. 6, was followed, using the formula set out therein for obtaining the breaking load per square inch of section. The results of some determinations of the resistance to wear determined by the use of a special machine designed by the author are given in the foregoing table, Table III. Both samples tested were of the same composition and from the same cast. The sand-cast specimens were prepared from standard ⅞ inch. diameter round bars, and the centrifugal-cast specimens were machined from cylindrical castings having a wall thickness of approximately ⅜ inch. The tests were made under strictly comparable conditions, and the extent of the wear in each specimen, as indicated by the loss in weight, is given in the table. These figures are the only long series that the author has yet available, and are taken on a material having a fairly high silicon content as indicated. The state of our knowledge of the factors governing wear in materials is insufficient to allow of the broad conclusion that these results are characteristic of centrifugal castings, and they are included merely as the results of a long comparative test. The figures in themselves are rather remarkable, indicating as they do a greater loss in weight in the centrifugal casting of the above composition in the earlier stages of the test. The

magnitude of this loss in weight in the centrifugal casting decreases as the test is prolonged, and has apparently reached a constant value, whereas in the sand casting the loss in weight increases steadily with the prolongation of the test. It is also worthy of notice that the combined carbon in the sand-cast specimen is higher than in the centrifugal-cast material. Investigations are being made as the opportunity occurs into the behaviour of centrifugally-cast material under the influence of high-temperature conditions on the elastic properties and other properties of interest in connection with high-grade castings. As in the case of sand castings, the composition of the material has a profound influence on all these properties, apart entirely from any influence of the method of casting, and up to the present time the tests made are more or less of an exploratory nature, with a view to indicating the most hopeful lines to work on. The data yet available are of too disjointed a nature for publication.

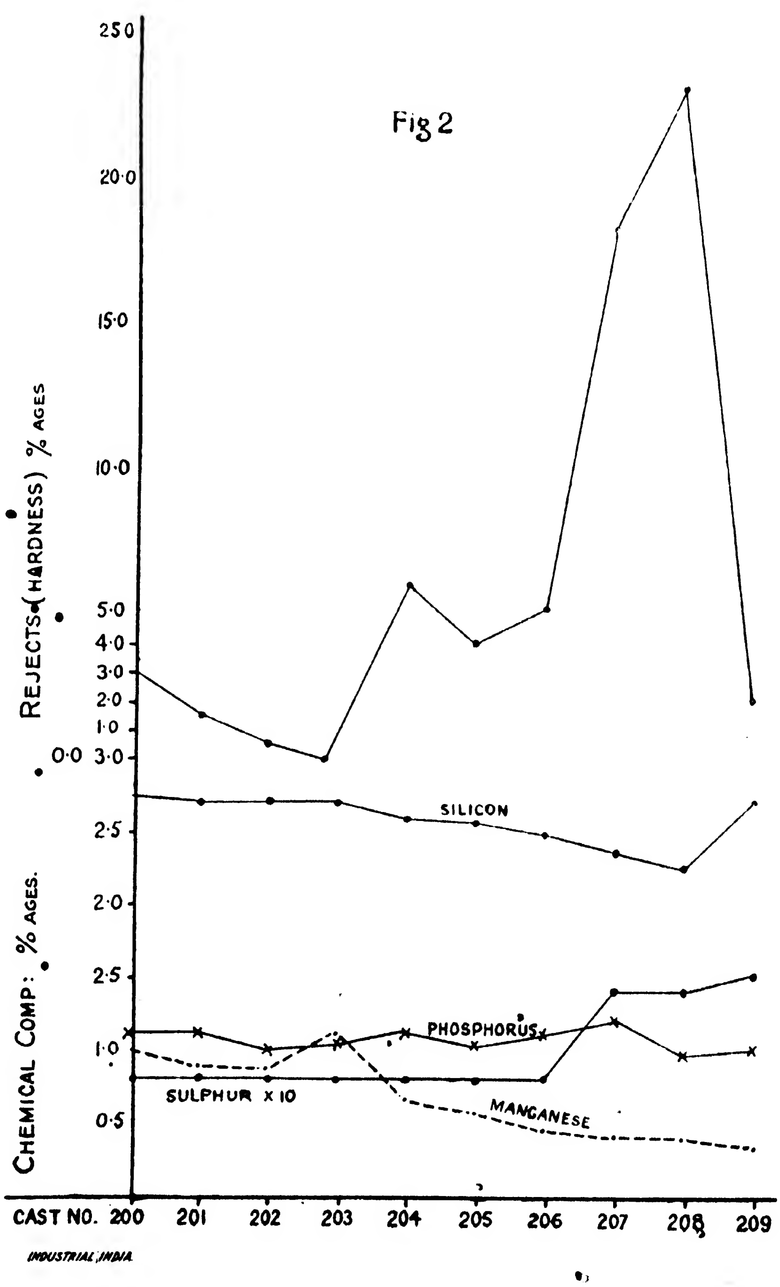
Structure of Centrifugal Castings

The freshly broken fracture of centrifugal castings in cast-iron is invariably very close grained. Neglecting a thin layer on the outside edge of the casting adjacent to the metal die, the fracture of the centrifugal castings produced under correct conditions is uniform throughout. The uniformity of the fracture is particularly noticeable in castings of comparatively large cross-sectional area.

Prof. Howe has found (Bulletin American Inst. Mining and Metallurgical Engineers, February, 1919, 361-365), in experiments made with a mixture of zinc with 5 per cent. type metal, that a marked spiral marking is obtained when cast in rotary moulds, as contrasted with the strong columnar structure when cast in stationary moulds. No evidence of spiral markings has been encountered by the author in connection with cast-iron, and in this connection it is to be noted that the Bureau of Standards found pronounced ingotism in the centrifugally-cast steel samples examined by them. (Technologic Paper No. 192.)

Beyond showing the reduction in size of the graphite, the author has not been able to show clearly the reduction in size of the grains corresponding with the evidence obtained by visual examination of the fracture. In certain experiments which have been made on non-ferrous alloys the grain size can be readily shown by modified etching methods. A series of photographs of a high lead bronze, centrifugally cast, were exhibited, showing the reduction in grain size of the centrifugally-cast material as compared with the original ingot. The author considers it legitimate to make the deduction that the grain size of cast-iron is similarly effected.

There is no doubt that this reduction of the grain size is largely responsible for the improvement of the mechanical properties noticed. It seems highly probable that the reduction in grain size is a direct result of the method of casting. There is no evidence that the pressure under which the metal solidifies has any influence on the structure or mechanical properties, and the reduction in grain size is sufficiently accounted for as a result of the motion and agitation of the metal during solidification.



Pinholes and Blowholes

From a consideration of the method followed in the production of cylindrical castings by the centrifugal process, it will be seen that the manner of solidification of the molten metal is somewhat different from that of similar castings produced by sand-casting methods. Neglecting the end effects in sand castings, the molten metal in cylindrical castings commences to solidity at the inner and outer surfaces to all intents and purposes almost simultaneously. The centre portion of such castings is the last to solidify, hence the necessity for risers and feeder heads to make up the deficiency of metal in the liquid centre due to the shrinkage of the molten metal. In the centrifugal process the mould is rapidly rotating about the horizontal axis, and as the metal is poured in it is rapidly whirled round, completely covering the surface of the mould, and as the molten metal is continually poured in each layer is covered by a successive layer at each revolution of the machine. If the casting has been poured correctly, and all the features of the mould and speed are correct, the solidification of the casting as a whole is practically complete with the last layer poured in, and consequently no feeding is required to make up the effects of shrinkage. If these conditions are not correct, then liquid shrinkage must occur, and this usually manifests itself in the form of markings on the inner surface of the casting, which are really slightly unsound portions resulting from the contraction of the final layers. Examples of this were exhibited in the form of photographs, and they are often accompanied by slight exudations or pellets resulting from the contraction of the inner portions forcing still liquid metal through to the inner surface. Analyses taken of the exudations show that they are not necessarily highly phosphoric, and this effect is often magnified by the condition of the machines and vibration. For example, any "out of balance" frequently accentuates the appearance of these markings. Neglecting the end effects, therefore, it will be seen that cast under correct conditions the solidification of the molten metal in centrifugal castings takes place from the outside surface to the inside, and the final portion to solidify is the inner surface.

The difference in method of solidification is one of the advantages of centrifugal casting process, and it is to this cause that the uniformity of the fracture can be ascribed, which in its turn is responsible for the high and regular values obtained for the mechanical tests taken on samples cut from the castings. Solidification in this manner is also responsible for the absence of unsoundness and porosity and the elimination of those deep seated blowholes due to incorrect casting temperature. Blowholes due to mould gases which are met with in sand castings are obviously absent, as no sand is employed in the process.

The phenomena of the occurrence of small pinholes in centrifugal castings has been referred to by Williams (I.B.F. Proceedings, 1920.) Small subcutaneous blowholes which were probably identical with pinholes were found in centrifugal cast steel castings. (American Bureau of Standards Technologic Paper, No. 192.) There are probably three types of pinholes which have distinct characteristics which enable them to be readily recognised. The first type are not really pinholes, but are minute superficial depressions which very rarely penetrate any considerable depth into the casting. These are due to entrapped air between the mould surface and the rapidly solidifying casting.

Pinholes

The second type of pinholes are probably the most serious, and are strictly pinholes in that they are very narrow holes, literally covering the outer surface of the casting, and extend a considerable depth into the casting. They may, and very frequently do, extend right through the casting, and often lead into a large patch of unsoundness, which is indicated by a characteristic rumpling of the inner surface of the casting. On the extreme outer surface the width of the holes may be large, but immediately they enter the casting they narrow and expand into a pear-shaped hole further in towards the inner surface. Many of the holes are found not connected with the outer surface, but with the opening on this surface completely sealed up. These isolated holes are almost invariably bright and free from oxide scale, but those open on the outer surface may or may not be coated with oxide scale. It is evident from this that this pinhole was formed during the actual solidification period as indicated by the bending of the primary crystallites clearly indicated in the photograph. On this and on other ground it is considered that the pinholes are due to the liberation of the dissolved gases during the solidification of the metal which are trapped in the casting under the particular conditions of rate of solidification obtaining.

Photographic Studies

A series of photographs taken from a crude brass casting were shown on the screen. The brass used during this experiment was crude material obtained by re-melting commercial scrap and probably had a composition round about 80-20, and containing large quantities of lead and tin. The photographs are taken from the outside and inside edges of the two castings respectively, and the specimens were etched with chromic acid to show the crystal boundaries. Casting No. 1 shows a comparatively uniform grain structure throughout, and, as a matter of fact, small subcutaneous pinholes were to be seen on the inside surfaces. Casting No. 2 shows a large collection of pinholes and unsoundness on the outside surface, and the grain size is not uniform throughout, the grain being much larger on the inner surface than the outer surface. In this casting the casting temperature was much higher than in the case of casting No. 1. It is probable that the influence exerted by the casting temperature is through its influence on the rate of cooling or rate of solidification, and these photographs are included to show the influence of the rate of solidification on the position of the pinholes in the sample.

The third type of pinholes cannot be separately distinguished, and the author has considerable doubts as to whether they exist. However, certain occurrences have led one to suppose that an insufficiency of plumbago in the mould is liable to cause pinholes. This is not altogether clear, nor is the reason why this should be so.

A considerable amount of investigation has been carried out on the subject of pinholes, which are the most serious of the metallurgical troubles which have been encountered, and sufficient is now known to be able as a general rule to prevent their occurrence.

New Brunswick.—This province has three paper mills operated by water power, with a total installation of 14,668 horse-power and a daily producing capacity of 30 tons of mechanical and 250 tons of chemical pulp.

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS

Oils and Lubricants

IN dealing with oils collectively, these can be divided into three distinct classes, namely mineral oils, vegetable oils and those derived from animal sources. Before attention is drawn to these classes, the actual valuation of an oil, that is how such value is determined, should be known.

When used as a lubricant, the value of an oil is chiefly dependent on its capacity as film-forming, which in other words means its capability of maintaining a film of oil between bearing surfaces. The viscosity of the oil to a great extent governs its film forming capacity, but it should not be misconstrued that the most viscous oil is likely to be the most suitable. It will be found that an oil of the lowest viscosity which will retain an unbroken oil film between bearing surfaces is the most suitable for lubricating purposes because a higher viscosity than that necessary to retain the oil film results in a waste of power due to the expenditure of energy necessary to overcome the internal friction of the oil itself. How the frictional resistance differs with various oils is shewn by the following figures. If the friction of a journal in its bearing using sperm oil is assumed equal to 1, the friction resulting from the use of rape oil is 1.06, mineral oil 1.29, lard oil 1.35, olive oil 1.35 and mineral grease 2.17.

Frictional Values

These different frictional values when applied to high speed shafts or spindles mean a large difference in the horse power absorption in driving, a factor that very clearly demonstrates that in lubrication the lubricants used is a question of much greater importance than generally imagined.

Mineral Oils

Nearly all commercial lubricating oils are obtained from petroleum, although some mineral oils are also derived from shale. Mineral oils are classed commercially as "pale" and dark." The pale oils are inclined to transparency, and are tinged with a variety of yellow and red shades. The dark oils are opaque and of a greenish and brownish black hue. The oils obtained from petroleum have a greater range of viscosity than fixed oils, the thinnest being more fluid than sperm oil, whilst the thickest more viscous than castor oil.

Lubricating oils obtained from shale are of a low viscosity.

Mineral oils are often artificially thickened by adulteration which will be later mentioned under the chapter of adulterants. The specific gravity of mineral oils varies between approximately 0.86 to 0.94, whilst their flash point is within the region of 300 to 600 deg. F.

Pure mineral oils have been found quite satisfactory for forced lubrication, but where lubrication is not of this character, friction pressure and spindle speeds must determine to a great degree the class of lubricant used. Pressures below 70 lbs. per sq. in. are generally accepted as light, and speeds below 100 ft. per minute as low speeds. Pure mineral oil may be used when the pressure is light, but over the light pressure maximum stated, blended oils should be used.

Vegetable and Animal Oils

The most common lubricants amongst animal oils are tallow, lard, neats foot and sperm oil, whilst with vegetable oils, olive, rape and castor oils are the best known. Oils that are obtained from the seeds of plants or fruits and the tissues of animals which will not volatise unless decomposed are known as "fixed oils." These oils become fats at low temperatures and inversely all fats become oils at 150 deg. F. Generally speaking, animal oils are yellow or either colourless, whereas vegetable oils have various shades of yellow and green. For internal lubrication, vegetable and animal oils are not suitable, owing to the decomposition that sets in at high temperature, forming acids which are injurious to metals. The combination of the following lubricants and metals tender towards corrosion. Tallow oil, iron and copper; seal oil, copper; whale oil, lead; lard oil, lead; sperm oil, lead and zinc; rape oil, copper; cottonseed oil, tin.

The specific gravity of fixed oil varies from about 0.88 to 0.96 at 60 deg. F. Sperm oil has the lowest viscosity and castor oil the highest.

Blown or Thickened Oils

Rape and cotton seed oil are those generally selected for artificially thickening. This is done by the forcing of a current of air through the heated oil which increases the density, and makes them more viscous. Mineral oils mixed with blown oils are greatly used for lubrication, especially when as previously stated the frictional pressure exceeds 70 lbs. per sq. in.

Mineral oils are not always mixed with blown oils, but are artificially thickened by means of the addition of some aluminium soap. By this addition, the viscosity of the oil is increased, but which rapidly diminishes with the application of heat. For thickening mediums to mineral oil, soap such as lime, soda or lead soap is often added to form

grease at ordinary temperatures. Solid lubricants such as graphite, talc, etc., can also be included in these greases.

Expensive oils such as sperm, olive and lard oils are often mixed with fixed and mineral oils for cheapness. Cotton-seed oil is sometimes mixed with olive and lard oils and often substituted for olive oil. With mineral oils adulterants are usually added for increased viscosity, and the presence of these adulterants can sometimes be detected by simple tests as will be described.

TEST 1.

To determine the presence of solid impurities in oils, kerosene is added to half a tumbler of oil until the whole becomes quite thin. On obtaining some filter paper or ordinary white blotting paper, the oil should be gradually passed through. This having been effected, the filter paper should be washed with kerosene and the residue left in the paper will show what impurities were contained.

TEST 2.

Impurities can also be roughly detected by smearing a piece of writing paper with oil and holding it to the light; if the oil is free from solid impurities, the resultant blot will be of equal transparency throughout, otherwise the solid particles must show. In either of these tests it is essential that the oil does not resinify. For the testing of this, pour a certain amount in a shallow dish for a week, and leave in a warm place; at the end of that time there should be no crust whatever.

TEST 3.

Oil can be tested by mixing with nitric acid fumes. If the oil is pure, a thick mass will form in a few hours, whilst resinifying oil will remain thin. The presence of acids in oil is very injurious to metals, as in time they attack the parts lubricated.

TEST 4.

To test for acid, pour some oil in a glass vessel, and add either copper oxide or copper ash. Free oil retains its original colour, whilst if containing acid it becomes a bluish or greenish colour.

TEST 5.

Let a drop of oil rest on a sheet of copper or brass, and leave it there for roughly a week; if the oil contains acid, the metal will show a green spot.

TEST 6.

Cylinder oil can be tested by colour. Good cylinder oil, when heated to 480 deg. F., will not change to any noticeable degree, or if heated to a temperature slightly higher than that which exists in a high pressure engine cylinder. Low grade oils, on the other hand, will darken when treated in this manner.

TEST 7.

Cylinder oil can also be tested by heating the oil in a current of air for one hour at a temperature corresponding. The loss in weight should not exceed 0.5 per cent.

TEST 8.

Take a small quantity of oil or grease in a test tube or wide mouthed glass jar and dissolve it in alcohol, the time taken being appreciably lessened by partly immersing the test tube or jar in a vessel of warm water. As soon as the whole has been reduced to a liquid state, a piece of blue-litmus paper, which is obtainable at any chemists, should be dipped in the mixture. If acid is present, the paper will turn red.

TEST 9.

This test, which takes several days to complete, consists of taking a few strands of wool or cotton waste, soaking them thoroughly in the lubricant to be tested, then wrapping them round a piece of brightly polished steel bar. The bar and strands should then be exposed to the full rays of the sun for a few days (sheltered from any rain), and then examined. If, after four days, the strands are removed, the bar rubbed with a dry cloth, and no marks are found on the steel, the oil is acid free, but should a dull line remain where the strands were bound, this line has been etched by acid in the lubricant.

TEST 10.

The last method to be included here is to mix a small quantity of the oil to be tested with an equal quantity of saturated solution of caustic soda. The mixture should be bottled, thoroughly shaken, and put aside for a couple of days. At the end of that time, if the oil has absorbed all, or nearly all, of the caustic solution, and has become a hard mass of soap, that grade of oil is of no use for lubricating purposes, as the amount of acid present is positively dangerous.

It will be seen that there are ample simple methods of testing oils for acid should any doubt exist as to its presence, which causes rusting or etching of brightly finished surfaces, this tending to roughen such surfaces and increase the friction.

Viscosity

A very simple means of comparing the viscosity of two or more oils is to take a glass plate, and after setting it at a slight angle from the horizontal drop upon it from a pipette or tube an equal number of drops of the oils to be compared. The thinner oil, or that of the least viscosity will at first flow rapidly down the plate. After a day or two a comparison can be made, the oil which flows the greater distance can be taken as the better example, if an oil of low viscosity is desired.

As regards engine oil, there is no standard, but it has been proved that a good lubricating oil should have a viscosity of 450 seconds at 100 deg. F., and 60 seconds at 250 deg. F. with a steady fall between these points for engine purposes.

The viscosity of all lubricants varies considerably with changes of temperature, and consequently when the viscosity of oil is spoken of, a definite temperature is understood and which is taken as 60 degrees F.

Effect of Heat

An oil might be sufficiently viscous to carry a given load under normal conditions, but become so fluid due to rise in temperature as to cause the bearing surfaces to cut and abrade each other. The viscosity of mineral oils varies more with the temperature than the viscosity of fixed oils, hence a bearing lubricated with a mineral oil needs more attention than one lubricated with a fatty oil. In general the viscosity of a lubricant should increase as the spindle speed diminishes and this is particularly applicable to mineral oils. As the loads increase, wear and overheating may result unless fixed oils be added, although it is rarely necessary to use pure fixed oils. The necessity for using expensive fixed oils, instead of cheaper mineral oils is sometimes due to imperfect lubricating devices. When selecting a lubricant for bearings operating at ordinary speeds, viscosity is the most important property to consider providing the loads do not exceed 200 to 250 lbs. per sq. in.

Machine Lubrication

For machine tool bearings, shafting and machinery of medium weight and speeds, a mixture of mineral oil with 10 to 20 per cent. neutral animal, or vegetable oil will be found suitable. Animal oils are to be preferred to vegetable oils, owing to their less liability to gum. For dynamos and motors with ring lubrication pure mineral oil should be used having from two-thirds to about three times the viscosity of rape oil, dependent upon the size, weight and speed of the machine. For ball bearings a neutral animal oil or fat, either pure or mixed with a fairly viscous mineral lubricating oil will be found satisfactory. For very light machinery running at fairly high speeds use mineral lubricating oil, having about the same viscosity as sperm oil, best results being obtained by the addition of 10 to 20 per cent. sperm oil.

For turbine bearings having forced or circulating pump lubrication, use pure mineral oil having a viscosity of from one to five times that of refined rape oil, depending upon the bearing pressure speed and temperature conditions. For steam engine cylinders use heavy mineral cylinder oils mixed with from 5 to 25 per cent. of rape or other fixed oil, the proportion of the latter being reduced as low as possible without imparing the qualities of lubrication.

For very heavy locomotives use mineral oil having from two to four times the viscosity of rape oil mixed

with refined rape oil in the proportion of three parts mineral to one part rape oil. In very warm climates it is desirable to increase the viscosity of the mixture by adding some good mineral cylinder oil.

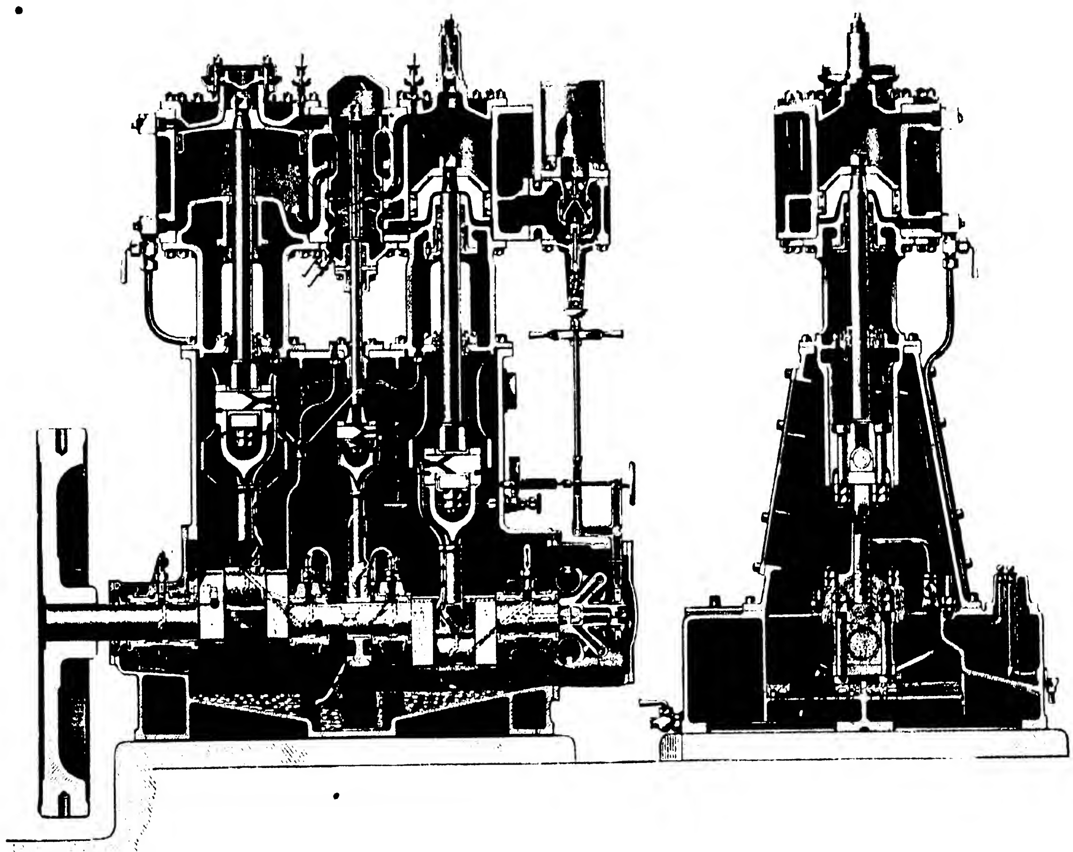
For gas engine cylinders, a mixture of 90 per cent. mineral oil and 10 per cent. neutral fixed oil is used with satisfaction.

Oils for Tempering: Flash Point and Fire Test

With oils used for tempering the flash point and fire test are two temperatures of an important bearing. They must not be accepted as one and the same thing, but are distinguished as follows:—The flash point is the temperature at which the amount of vapour given off is sufficient to form an inflammable or explosive mixture with the air over the surface of the oil, so that the gaseous mixture ignites and burns with a momentary flash, when a flame is applied. As the temperature of the oil rises more vapour is given off, and when the production of vapour is rapid enough to maintain a continuous flame, the oil takes fire and burns, this temperature being known as the "fire test." It is possible to obtain a temperature of from 650 deg. F. to 700 deg. F., with heavy tempering oils but a tempering oil that has been recognised to give most satisfactory results has the following characteristics:—composition, mineral oil 94 per cent. saponifiable oil 6 per cent. specific gravity 0.920; flash point 550 deg. F. fire test 625 deg. F. These figures apply to new oil, but when continually used so as to become practically useless, an analysis of the same composition, has resulted as follows:—Mineral oil 30 per cent.; saponifiable oil 70 per cent., specific gravity 0.950; flash point 475 deg. F. fire test 550 deg. F. The difference here is due to the loss of mineral oil resulting from the high heats to which tempering oil is frequently or constantly subjected; hence the durability of the tempering bath can be increased by occasionally adding new mineral oil.

Cutting Lubricants

Lard oil as a cutting lubricant is extensively used especially on automatic screw machines, where steel or wrought iron is being worked upon. One unsatisfactory point about lard oil against other commercial lubricants is that being of a sluggish nature it does not penetrate to the cutting point with sufficient rapidity, where high cutting speeds are in operation. Nevertheless, lard oil is frequently used in combination with other lubricants for general machining purposes. There are many patent lubricants on the market now-a-days, all differing slightly in their composition, which find great favour with manufacturers, but for those who choose to prepare their own, the following cheap lubricant is recommended for turning, milling, etc., and should be prepared in the following proportions; one pound of car-



Section showing Lubricating System of a modern High-speed Engine

Belliss & Morcom, Ltd.

bonate of soda; one quart of lard oil; one quart of soft soap and enough water to make 10 to 12 gallons. This mixture should be boiled for half an hour. Any objectionable smells can be eliminated by the addition of two pounds of slaked lime. For deep hole drilling, plain milling and threading operations, equal parts of lard oil and paraffin mixed will be found very satisfactory. For gear-cutting a mixture of 3½ gallons of mineral lard oil; 2¾ lbs. of carbonate of soda to a barrel of soft water has been proved extensively to possess great cutting qualities. For work on nickel steel and similar tough material with machines running at high speed, the following compound has proved satisfactory. To 8 gallons of warm water add 25 to 30 ounces of borax. When fully dissolved add two gallons of lard oil, and stir thoroughly. When cold, add the contents of a No. 10 jar of "Aquadag" (condensed), and mix thoroughly.

A cheap drilling composition can be made by adding to 30 gallons of water, 5 gallons of lard oil, and 20 pounds of washing soda. Put the composition in a lard oil barrel, invert a steam hose into the bung and boil thoroughly. Do not use mineral oil or a barrel that has contained it.

For machining copper, milk is generally considered to be the best lubricant, but lard oil and turpentine mixed is extensively used.

There are many opinions as to the best lubricant for machining aluminium, but the majority are based on or around kerosene. As a rule soap water and kerosene are generally employed.

Smoke Abatement

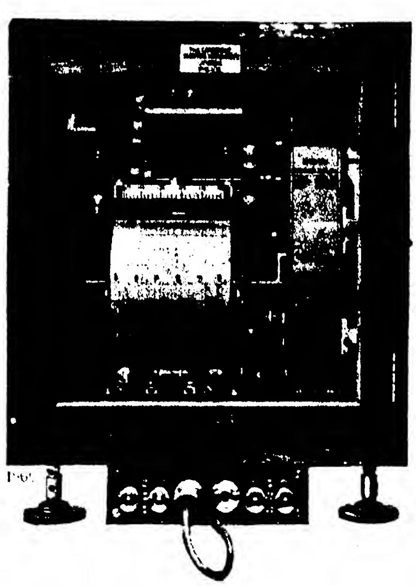
At a recent conference between the Wakefield City Health Committee and local manufacturers when the final report of Lord Newton's Committee was discussed; addresses were given by a number of authorities on this important subject. The following extracts are taken from Mr. W. H. Casmey's address which deals at some length with the question of grate area.

DURING the last 20 years I have lived in Wakefield, but during that time nothing has given me greater pleasure and pride in our sleepy old city than to-day's meeting, which indicates the first practical step in an economy campaign, which will dwarf the Geddes Axe completely, and the lead given by Wakefield will very quickly be followed by other industrial centres, and the total results will be

A saving of 50 millions tons of coal per year, a proportionate reduction in the cost of producing steam, therefore cheaper power and cheaper products.

A purer atmosphere, more sunshine in our cities and towns, fogs with their inconveniences minimised, happier and healthier people and a greatly reduced death-rate, surely such benefits are sufficient to make one proud of being a rate-payer in the city taking the first step towards such attainments.

We are all satisfied without medical knowledge that the two chief essentials for good health are water and air, consequently both should be free from pollution, but only the water seems to secure attention, and yet the senses of sight, smell and taste enable us to reject it when impure, but no matter how polluted the air is by which we are surrounded we are compelled to breathe it, and we who would not drink from anothers glass, do not hesitate to inhale the products of combustion from the lungs of others which may be diseased. Knowing that pure air is necessary for health where is there any reason in overcrowding houses, schools, music halls, and trams and trains, and to then express surprise at the spread of even air borne diseases, including Tuberculosis, as we make the conditions we can only expect the natural results of our own work.



Single Point Temperature Recorder — The Cambridge & Paul Instrument Co. Ltd.

It is only natural to ask the question: How does wasted coal affect public health?

Combustion in a domestic grate, a boiler furnace or the human frame is governed by the same law, the maximum results being secured in each case when air and fuel or food are of the best and served with the correct proportion of air for chemically uniting with it, such combination producing heat.

It is impossible to secure the best work from a boiler if the furnaces are supplied with the products of combustion from the flues, and it is equally as futile to look for healthy lives when people are breathing over and over again each others breath, and to prevent such conditions the following lines should be followed:—

Coal and other fuels should be burned correctly, and perfect combustion would be secured and the formation of smoke prevented, therefore that of air pollution also.

All our public buildings, especially schools, should be fitted with ventilating plant suitable for keeping the inside air pure, quite independent of the number of people occupying the building.

As pure fresh air is one of the principle cures for lung diseases, lack of it has the opposite effect, poor health is therefore the result of poor engineering in fitting up our buildings, just as black smoke and wasted coal are in connection with our steam boilers.

In the United Kingdom there are approximately 80,000 boilers working, using say 100 million tons of coal annually, and our total population are accommodated in about eight million houses, the coal consumption being 40 million tons, or five tons per house per year, and there is no practical reason to prevent this 140 million tons of coal being reduced by about one third and still give the same results.

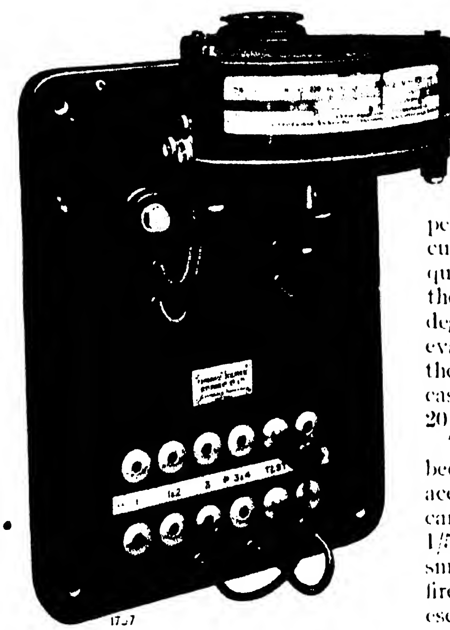
Our total yearly coal consumption is at the rate of 1,600 tons per square mile of the whole area of the Kingdom, but for the rateable area of Wakefield, the coal consumption is 25,000 tons per square mile, and for Bradford, about 37,000 tons per square mile, and in face of these facts there is no wonder at the high death rate amongst children in our industrial towns, nor yet at the closing of day schools for weeks together due to infectious diseases.

The domestic firegrate may be taken as an introduction to the more practical side of our subject, is one of our most hygenic institutions, due to the fact that it makes ventilation compulsory, and if as suggested by the recent report of the Smoke Abatement Committee, the open fire is replaced by the gas fired increased sickness would soon follow.

The general idea of using the domestic grate economically is to allow the fire to burn until only a few red cinders are in the grate, a shovelfull of coal is then dumped on and smoke is at once formed and escapes up the chimney, in process of time blocking the chimney with soot, and the sweep is called in to take the obstruction away to enable the economical householder to carry on the same practice.

When coal is added to a fire gases are liberated, and if the temperature of the fire surface is over 900 degs., they are at once ignited and heat is radiated into the room, but if the temperature is reduced by the fresh coal below 900 degs., smoke is given off until the ignition temperature is reached, by which time probably the bulk of the gaseous portion of the coal, say 25 per cent. to 30 per cent., has passed up the chimney, in other words wasted.

To prevent this wastage of coal, fresh fuel should be added to the fire in small quantities, and when it is clear and bright the liberated gases would then be at once ignited and more heat radiated into the room per pound of coal burned.



Differential Thermometer

The Cambridge & Paul Instrument Co. Ltd

The size of firegate for a sitting room should be in the proportion of 1 square inch of grate to 9 square feet of floor space, and as heat passes through glass six times as rapidly as through a brick or stone wall, it is well in winter to drop the bedroom blinds during the early part of the afternoon, this simple expedient helps in keeping down the coal bill.

Cause and Prevention of Smoke in the Boiler House

The real cause of coal wastage in the boiler house is neglect of natural laws, and such wastage stops immediately we reverse our methods of working.

The engineer, to succeed in boiler house practice, must study the laws of gravitation, expansion of gases, friction, combustion, radiation, heat transmission and circulation, as well as the quality of water and fuel he has to use, but we are only looking at the subject this afternoon in a cursory manner.

To burn one pound of coal economically and usefully, 18 lbs. of air are required (this equals 234 cubic feet), the furnace temperature with such proportion will be 2750 deg. and other parts of the plant being in good order the boiler will give approximately 80 per cent. efficiency or with ordinary slack an evaporation of 10 lbs. of water per pound of coal.

In general practice however, taking the tests of over 1,000 boilers, the average weight of air per pound of coal was 30 lbs., or 390 cubic feet, and when using the same quality of coal as in the previous case the furnace temperature is only 1,700 deg. boiler efficiency under 60 per cent., evaporation per pound of slack $7\frac{1}{2}$ lbs. therefore 15 cwts. of coal in the first case gives the same evaporation as 20 cwts. will give in the second.

The natural question is: what has become of the 25 per cent. of coal not accounted for in the boiler? and on careful inspection will show about 1/5 of it in the form of cinders and small coal under the bars, due to thin fires, the same amount will have escaped as smoke and the balance in heating up uselessly the 12 lbs. of excess air; black smoke it is well to mention contains two grains of carbon per cubic foot, and if 390 cubic feet of air are supplied per pound of coal, and this volume owing to increased temperature is doubled on leaving the boiler, therefore during a black smoke period 1,540 grains of coal are lost from every pound used, or over 25 per cent.

The rate of heat radiation with a furnace temperature of 2,750 degs., is three times greater than when the temperature is 1,700 degs., therefore, with a clean boiler 10 square feet of grate at 2,750 degs. will do as much work as 30 square feet of grate, with a temperature of 1,700 degs., this fact raises another important question.

Do we give in our steam boilers the correct proportion of grate area and outlet at the ends of the furnace flues through which the products of combustion are to escape to the external flues?

From a long personal experience I am satisfied the proportion in question

should be 2 to 1, but in daily practice it will be found this ratio varies with every diameter of boiler from 4 to 1 in a boiler 7 ft. diameter to 2.7 to 1 in one 9 ft. diameter, in plainer words this means that with equal chimney draught 2.7 square feet of grate in a 9 ft. diameter boiler will give the same evaporation as 4 square feet in one 7 feet diameter.

By giving in all sizes of boilers the same 2 to 1 ratio of grate to outlet, the thickness of the fires would have to be increased, and this would automatically cut down the excess air, give an increased furnace temperature, make black smoke impossible, and increase both the duty and efficiency of the boiler.

That the modified form of grate is not of the bee-in-the-bonnet style, may be judged by the fact that the Head of the Ministry of Munition Inventions Board granted an award for this suggestion in November, 1917, after three months experiments by Government experts.

The following extracts from letter received from firms who have adopted the 2 to 1 suggestion is an additional proof that big coal savings can be effected by using the same care of proportion in the boiler house as in every other part of the works.

(1) We have four Lancashire boilers 30 ft. by 8 ft. by 120 lbs. pressure, machine fired (coking-stokers) grates were originally 6 ft. long, but are now 3 ft. 10 ins. long. On the four boilers we are saving nearly 800 tons of coal per year. Our overall efficiency is over 84 per cent. We use induced draught.

(2) Two 30 ft. by 9 ft. Lancashire boilers 160 lbs. working pressure, sprinkling stokers used, length of grates 3 ft. 6 ins. deadplates being 2 ft. 6 ins. long: engines 800 h.p. evaporation per pound of slack 9 lbs.

(3) Three 30 ft. by 8 ft. 6 ins. boiler grates reduced from 6 ft. 6 ins. to 4 ft.: saving in coal over 20 per cent.

(4) 30 ft. by 8 ft. 160 lbs. pressure: reduced the grates from 6 ft. to 4 ft.: saving in my coal bill, equal to 140 tons per year over a period of 21 months.

(5) We have three Lancashire boilers, 30 ft. by 8 ft., have reduced grates from 6 ft. 6 ins. to four feet: have made a saving in fuel at the rate of 9 cwts. per 12 hours shift—this over the last six months.

(7) Since reducing the length of our boiler grates from 6 ft. to 4 ft., we have saved 10 per cent. in fuel.

(8) We have reduced our 30 ft. by 8 ft. boiler grates from 6 ft. to 3 ft. 9 ins., and have saved two tons of coal per week over the last 18 months.

(9) Have reduced boiler grates by one third: have reduced coal bill and stopped black smoke.

Power House, indicating use of Distance Thermometers — *The Cambridge & Paul Instrument Co. Ltd.*

(13) A battery of 13 boilers under treatment: grates are being reduced 25 per cent. The firm on completion of alteration to the first boiler expressed themselves as satisfied with the improvement.

The most important conclusions to be drawn from the foregoing may be summarised as follows:—

The temperature of combustion is constant, but too high for steam-raising; but with a constant supply of air, say 18 lbs. per pound of coal, the resulting temperature is also constant, every pound of excess of

air is directly or indirectly equivalent to an additional 1 per cent. loss in fuel.

A flame flued boiler gives its highest duty and efficiency when the fire-grates are not more than twice the area of the outlet for the products of combustion at the ends of the furnace flues.

The terminal temperature alone is no guide to a boiler's efficiency or duty, a boiler is giving the best results which has the greatest difference between its initial and terminal temperature.

Some Essentials to be Remembered

Do not use more than four shovelfulls at a stoking. Keep the bars well covered, especially at the back.

Do not let the steam gauge indicate when to fire, nor let the chimney tell the smoke inspector when the boiler has been fired.

Stoke when the fires are at their best, but never stoke when the chimneys still smoke, since this is a sure indication that the fires are not hot enough to ignite the gases, and more coals only make bad worse.

Do not keep the furnace doors open for any purpose longer than can possibly be helped.

Do not forget that a fire grate 4½ ft. long is more economical than one 6 ft. long.

Finally, remember that the above suggestions are the outcome of practical experience, and if adopted will reduce work, save the employers money, give a purer air for all to breathe and assist the Government in its present difficulties.

Some Practical Notes and Observations on Land Type Boilers

By Captain H. J. WELLINGTON, M.C., A.M.I.Mech.E., A.M.I.A.E.

At a recent meeting of the Association of Engineers - in - Charge Captain Wellington read a paper reviewing in a very practical manner the principal types of land boilers, dealing with some of the leading features of each type. We reproduce below the first portion of Captain Wellington's paper.

WHEN one starts talking about boiler efficiency, one is on rather dangerous ground; we must approach the question either from the point of view of:—

(1) Test efficiency: or

(2) Normal working efficiency.

As regards test efficiency, reliable figures are available of tests on modern boilers that show a combined efficiency of boiler, superheater and economiser equal to 85 per cent. Of course, this is working under ideal conditions and with very high grade coal.

When one comes to investigate the working efficiencies of boiler plants it will be found that nothing like this figure is approached, and that eminent engineer, Mr. David Brownlie, stated in a recent paper he read before the Institution of Mechanical Engineers, that during a complete scientific investigation of over 400 boiler plants in Great Britain, he found the average working efficiency of the plants was 58 per cent.: that will give you a rough idea of the appalling waste of coal going on every day.

I am not suggesting that this average figure of 58 per cent. for these 400 plants could be brought up to 85 per cent. efficiency, but with a little care and careful supervision on the part of the engineers-in-charge, this figure could easily be raised to, say, 65 per cent. at least, and possibly more.

Lancashire Boiler

In dealing with smoke-tube boilers I take the Lancashire boiler first, as undoubtedly for medium sized requirements this is the most used boiler in the United Kingdom to-day.

The Lancashire boiler was invented by Sir Wm. Fairbairn, in 1844, and except for details it is to-day unchanged from the original design, and still remains one of the most successful types ever invented. It is, as you all know, a cylindrical internally-fired boiler with two or more flues and is set in brickwork, the fuel being burnt on the grate at the forward end of the flue. The hot gases pass along the remainder of the flue into the combustion chamber at the back end and thence along a brick flue immediately under the boiler to the front of same, where the gases divide and pass along two brick side-flues, either direct to the chimney or, in the case of an economiser being installed, the gases pass through this before reaching the chimney.

Occasionally one finds the path of the gases being reversed and passing along the side-flues first, and finally under the boiler (as in the case of a Galloway boiler, wherein this is done for special reasons), but this practice, in the case of Lancashire boilers, is not to be recommended.

Not very long ago I found that some Lancashire boilers that had been installed about 50 years ago, and were being pulled out, had simply been placed in a pit, and the gases, after leaving the internal flues, just went into the pit under the boiler and away to the chimney; it is not to be wondered that the owners of these boilers were complaining bitterly at their fuel bill.

Up to 1902, the usual practice was for Lancashire boilers to have flat ends stiffened by a number of gusset and longitudinal stays, and this type of boiler is still largely made to-day, the front ends being fastened to the shell plates by an external angle ring: the back ends, however, are

flanged inwards and riveted to the shell. The reason I refer to the different methods of fixing the front and back ends is that in the pursuit of my profession I have been surprised at the number of engineers that have not the least idea of the reasons for this difference. The reason for the ends of Lancashire boilers being different, is that in a well-designed Lancashire boiler at least 10½ in. should be allowed between the furnace rivets, and the rivets of the gusset stays in order to allow breathing space, and also to prevent grooving,

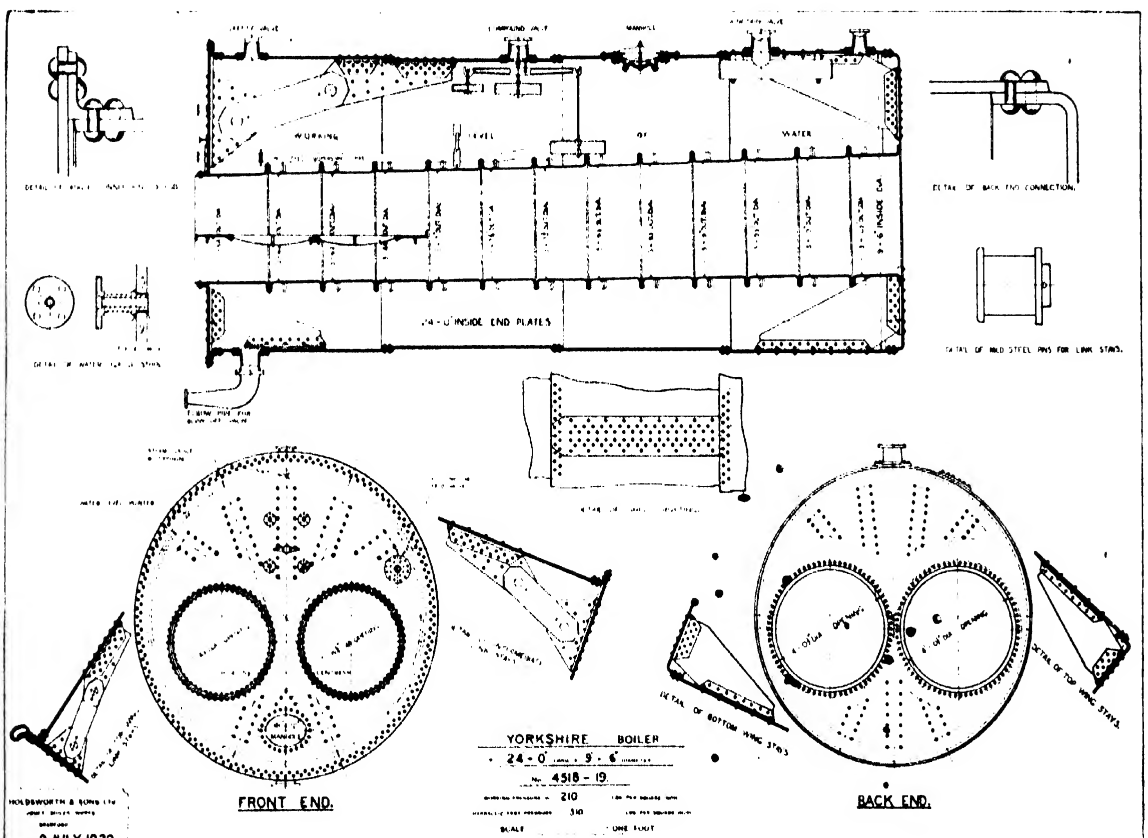
As regards the life of a boiler and prevention of grooving and sundry troubles, a great deal depends on the fitting of the gusset stays, and in a Lancashire boiler made by a reputable maker, as much care has been taken in fitting these stays as in fitting the main bearings of a high class engine. The end plates are usually stayed with from six to nine gusset stays.

About 1902, Mr. John Thompson, of Wolverhampton, introduced his dish ended self-staying boiler, which has proved most satisfactory and is

are no gusset stays to hinder this work.

The dish-ended boiler is, of course, cheaper to manufacture for many reasons, the chief one being that there are no gusset stays to fix, which represents a large proportion of the manufacturing costs.

The dish-ended boiler is also a much neater job than a flat-ended boiler, and also the inverted furnace mouths are a great advantage, as they allow the fires to be further back in the boiler, thus preventing overheating of the end plate and tending



Section through Yorkshire Boiler

Holdsworth & Sons Ltd.

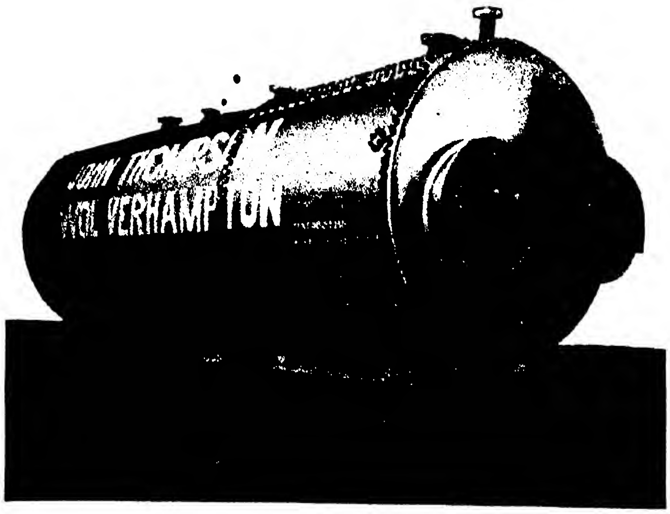
and if the front end where the furnace is largest in diameter were flanged inwards and riveted, it would be destroying valuable space, and would cause trouble. With the back end it would be unpractical to have an angle iron riveted to the shell as the hot gases in the combustion chamber would soon burn this away and cause trouble, but space at the back end is not at such a premium, for the furnace flues taper towards the back end, and this easily gives the 10½ in. required.

largely used to-day. Both the front and back ends are dished to a convex form and increased in thickness to give the required factor of safety, and here all gusset and longitudinal stays are dispensed with. Greater freedom is allowed for the unavoidable expansion and contraction strains set up in all internally-fired boilers, and the rivets connecting the end plates to steel and flues are subject to a shearing, instead of a tensile strain. Also it is easier to clean the end plates and steel plate nearest the end plates, as there

to stop grooving, which is a trouble to be guarded against in the Lancashire type of boiler.

The shell of a modern Lancashire boiler usually contains five or even less belts, each belt being a single plate; in older pattern boilers often six or more belts were used and were made up of two plates and sometimes four.

Corrugated flues are now often fitted to the Lancashire type of boiler, but care should be exercised when specifying these to ensure that they



Dish-ended Boiler *John Thompson (Wolverhampton) Ltd.*

are made with proper corrugated rolls, and not pressed in section under hydraulic presses.

A very easy and reliable way to arrive at the evaporation of a Lancashire boiler is to multiply the grate area by 140; this is based on burning 20 lb. of fuel per square ft. of grate area, and assumes that each pound of fuel evaporates 7 lb. of water.

The remarks with reference to the Lancashire boiler apply in every way to the Cornish boiler. The only difference between the two boilers is that the Cornish is a smaller boiler and has only one flue, whereas the Lancashire has two flues.

Cornish Multitubular Boiler

There is also a type of boiler called the Cornish Multitubular type, or sometimes referred to as the combined flue and tubular type boiler, which is really a hybrid boiler. This type of boiler is an elongated type of Cornish boiler, the front half of which is like an ordinary Cornish boiler; then comes the tube plate, and the gases are carried by means of smoke tubes to a smoke-box at the back end of the boiler whence they pass to the chimney. This boiler is chiefly used for heating installations.

Gunboat Boiler

Another type of boiler somewhat similar to the Cornish Multitubular is the Gunboat boiler, which is a long boiler on the same lines as the Cornish Multitubular, except that between the end of the flue and the tube plate in the centre of the boiler is a steel combustion chamber suspended and supported by stays, on similar lines to a wet-back marine boiler. A battery of this type of boiler has just recently been installed in the New County Hall, Westminster, for heating purposes.

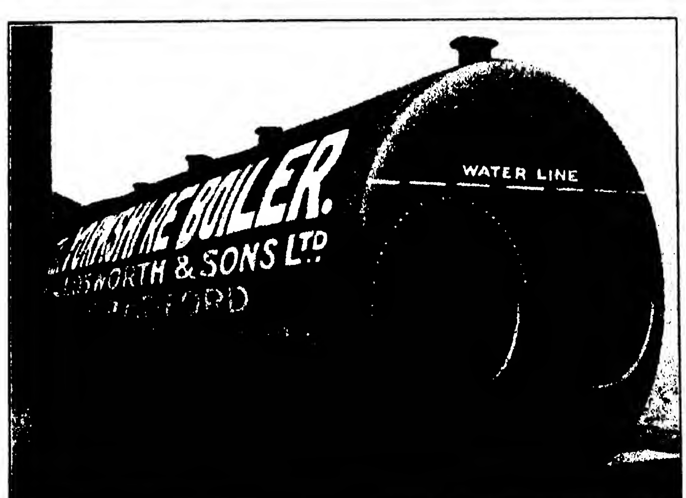
Yorkshire Boiler

The Yorkshire boiler is built on similar lines to a Lancashire, but is shorter, and the flues instead of tapering towards the back end expand from the front to the back in the proportion of two to three. The length of a Lancashire is generally 3½ times its diameter whereas the Yorkshire is only 2¼ times its diameter. This expansion of the flues gives a proportionally larger heating surface than with tapering flues. The gases on leaving the furnace meet with a constantly increasing sectional area, and this decreases their density, which creates a good draught.

Economic Boiler

The Economic boiler, as its name implies, is an economical and efficient boiler; it is really a dry back marine boiler adapted to land conditions and set in brickwork.

This boiler was first introduced some 40 years ago by that eminent engineer, Mr. James Paxman, the founder of the firm of Davy, Paxman & Co., of Colchester. It is a cylindrical, internally fired boiler with either one or two flues, according to size; the products of combustion pass through the flues as in a Lancashire boiler, and into a brick combustion chamber at the back; the gases then return through smoke tubes to the front of the boiler into a smoke-box, where they are divided and finally pass along brick side-flues to the chimney, so that the gases are passed twice through the boiler and once round the outside of the shell. The makers claim an efficiency of 75 per cent. for this boiler, this being between 10 and 15 per cent. greater than that obtained normally from the Lancashire. This high efficiency is chiefly due to the large heating surface, and the fact that the gases are passed twice through the boiler, and the maximum amount of heat is extracted from the gases before they pass to the chimney. The temperature of the gases leaving an Economic boiler is between 450 deg.



Back View of Yorkshire Boiler *Holdsworth & Sons Ltd.*

and 475 deg. Fahr., this being sufficient to create a good draught, whereas the temperature of the gases leaving a Lancashire boiler is generally between 600 deg. and 700 deg. Fahr. To put the comparison in a nut-shell as regards efficiency, the Economic boiler is equivalent to a Lancashire boiler with an economiser, but occupies about half the space required by a Lancashire boiler, and about one third of the space of a Lancashire with economiser.

For purposes of comparing size, it is found that the evaporation of an Economic boiler of 14 ft. by 7 ft. 6 in. is about the same as that of a Lancashire boiler of 30 ft. by 7 ft.

There is not much difference in the cost of Economic and Lancashire boilers but a considerable saving is effected in the brickwork of the Economic owing to it being only half the length of the Lancashire.

Some very fine results as regards evaporation have been attained with this type of boiler, and in an independent test by Sir Alexander Kennedy, an evaporation of 12.2 lb. of water per pound of coal was obtained, from and at 212 deg. Fahr.

Many engineers are at first rather shy of the smoke tubes, but provided proper care is given to the boiler these should certainly not give any trouble for the first 15 years, and I personally know of two boilers of this type in London, which were put in 26 years ago, and construucted for a working pressure of 200 lb. per square inch, and are to-day working at that pressure with the original tubes. Should it, however, be necessary, say after 15 years, to re-tube a boiler, this is not a very formidable task and can be done in four days by a skilled boiler-maker and his mate.

The Economic boiler is certainly not quite so easy to clean as a Lancashire boiler, but with a little care and ingenuity this can be accomplished quite easily. In the design of these boilers special care has been paid to accessibility, and it is quite easy in a moderate sized boiler for a man of average proportions to enter at the bottom manhole, and climb up between the furnaces and the nest of tubes, and come out at the top manhole. The tubes are arranged in two nests, with a space between them, this space being above the space between the flues and of sufficient width to allow a man to get through.

The makers state that provided the feed water does not exceed 20 per cent. of hardness and the boiler is properly looked after, periodically cleaned, regularly blown down, and a reliable boiler fluid used, no harm will be done, and that has been my experience; but I am always in favour, whatever type of boiler is used, of having a water softener installed, as it undoubtedly pays for itself in every way, and with an Economic, the saving in cost of the economiser will more than pay for a water-softening apparatus.

The staying of the end plates, which are flanged inwards, is effected by longitudinal stays and stay tubes; that is to say a certain proportion of the tubes are screwed into the end plates instead of being riveted and thus gusset stays can be eliminated.

The argument against the Economic boiler that I have often heard advanced, is that it has a small reserve steam as compared with a Lancashire, and this is supposedly a disadvantage where a boiler is required for an intermittent load. Personally, I do not see the force of this argument, for another pound of steam has to be generated for every pound that is taken from a boiler in order to maintain the pressure, and therefore, as the Economic boiler is a quicker steaming boiler than the Lancashire, it should be better in this respect.

The Economic boiler is also made in other modified forms, namely, the semi self-contained type and the self-contained type.

In the semi self-contained type, there is no brick setting, with the exception of the combustion chamber at the back; the gases after passing through the smoke tubes come into a marine uptake, and are led straight to a steel chimney. The advantages of this type are that it is more or less a semi-portable boiler and also takes up even less space than a brick-set Economic, also costs less to instal and there is not the necessity to have a brick shaft, as a steel chimney can be mounted on to the marine uptake smoke box.

In the entirely self-contained type all brick-setting, including the combustion chamber, is obviated; the boiler shell is extended to form the combustion chamber, this being lined with fire bricks. In other respects it is similar to the semi self-contained type. The self contained type of boiler is very suitable for export work, where it is impossible to obtain skilled labour for the erection of the boiler

As regards efficiency, it would be expected that this is lower in the semi self-contained Economic boiler than in the brick-set type. But experience has proved that when the three types of boilers have been tested over a straight run of, say, eight hours, there is practically no difference in their efficiences. The reason for this I put down to the fact that after the gases leave the smoke-box their temperature is such that they are unable to impart much, if any, additional heat to the shell of the boiler, but the gases in the side flues act as a 100 per cent. lagging, and it will be found that the banking losses on the semi self-contained and self-contained types are greater than with the brick-set type; of course, I am assuming that the semi self-contained and self-contained types are lagged with at least 2 in. of suitable asbestos lagging.

WATER POWER PROGRESS IN GREAT BRITAIN

A large and important hydro-electric scheme for Scotland was recently sanctioned by Parliament. This scheme covers a large area of the Grampian Hills, and involves the raising of the water level of more than one well-known Scottish Loch. There will be four power stations, capable of giving a continuous supply of fifty six thousand horse power. The electricity so produced will be distributed over a wide area for all purposes.

ORGANISATION

Conducted by HARTLAND SEYMOUR

THIS SECTION DEALS WITH WORKS MANAGEMENT AND ORGANISATION, THE TRAINING AND WELFARE OF THE WORKERS, AND WITH THE ADVERTISING, SELLING AND MARKETING OF GOODS

International Labour Conference

By G. M. BROUGHTON, M.A., O.B.E.

(Adviser, Labour Bureau, Department of Industries, Government of India.)

In the following article Miss Broughton deals with the different items discussed at the third International Labour Conference, which was held at Geneva with Lord Burnham as President, and delegates and advisors from practically all over the World.

READERS will perhaps be interested in a brief account of the origin of the International Labour Organisation and of its functions. The Peace Treaty signed at Versailles established, as an integral part of it, an International Labour Organisation. No small credit for this achievement is due to the British Government and particularly to Mr. G. H. Barnes, one of Great Britain's delegates at the Peace Conference. The objects of this organisation may perhaps best be summarised in the words of Mr. Barnes himself. In an essay that he contributed to Mr. Solono's book entitled "Labour as an International Problem," he writes: "The Conference holds in it the seeds of a vast and far-reaching international combination, not only of workers, but of Governments and employers; indeed of all the human forces of industry. The express object of their co-operative effort is to establish the production of wealth throughout the world on a foundation of justice and welfare for the workers." This prophecy is already in process of being fulfilled. Governments', employers' and workers' delegates at Geneva all proved that they were actuated by the desire to establish the well-being of those engaged in agriculture and in industry on a sound humanitarian foundation. At times they differed as to how this end was to be achieved but, in spite of these inevitable differences, they invariably treated the opinions of opposing parties with courtesy and respect. The importance of thus bringing together in one assembly Government representatives and employers and workers can scarcely be over-estimated. There can be little doubt, to quote the words of Lord Burnham, that "this international assembly is destined to wield an influence of paramount importance in the industrial affairs of the whole universe."

The Agenda

We may now examine in detail the items on the Agenda of the third International Labour Conference. These items covered a large range of subjects, but the chief aim of the majority of them was to secure, as far as possible, for agricultural workers benefits similar to those which the Washington Labour Conference had recommended on behalf of industrial workers. There are, however, many practical difficulties rendering it almost impossible to deal with both these classes of workers in the same way, though it may be ethically indefensible to make any distinction between them. Industrial workers are, on the whole, a fairly compact body organized to a greater or a lesser extent. Legislation can both be passed and enforced affecting the conditions of their employment. The case of agricultural workers, especially in a vast country like India, is very different. The workers are, on the whole, unorganized and even if the attempt were made to pass legislation to improve their conditions of work, it would be impossible to enforce it without creating so large an inspecting staff, that the cost of salaries alone would be an intolerable burden on the State. Again, factories and factory conditions are, within certain wide limits, approximately the same throughout the world, while there is the greatest diversity in agricultural conditions in different countries. Legislation, therefore, that is feasible for one country, may be quite impractical in another with differing conditions.

Such then were some of the difficulties with which the Conference found itself confronted in its attempt to level up the conditions of employment of agricultural workers. That the attempt was made, however, shows that the subject is worthy of serious consideration, and may be taken as a sign that all classes of workers throughout the world are determined to improve the conditions under which they have to live and work. Consequently, even though it may not yet be a question of practical politics in India to give immediate effect to all the recommendations and draft conventions passed at Geneva, yet the time will undoubtedly come when this country will be required to satisfy the other countries of the world that it is doing everything that is possible to ameliorate the lot of agricultural workers.

Agriculture

Seven recommendations and three draft conventions were passed relating to agriculture. Of these two recommendations dealt specifically with women, namely, with their protection before and after child-birth, and with their employment at night. The night work of children and young persons formed the subject of a separate recommendation. The other four related to measures to be taken for the prevention of unemployment, the development of technical education, living-in conditions, and social insurance. The three draft conven-

tions dealt with the age of admission of children into agriculture, rights of association and combination and workmen's compensation. Before dealing with each of these in turn the difference between a draft convention and a recommendation may be noted. A draft convention embodies in a rigid form the resolutions carried by a two-thirds majority of the votes of the delegates at a full session of the Conference. Each country belonging to the organization has then to bring the matter before its own legislature. If it is accepted then the country "ratifies" the convention, and has to proceed to see that every detail is duly enforced. If, however, the Legislature refuses ratification no further obligation rests with the State. A recommendation is more general in its terms than a convention, and is capable of modification to suit the particular conditions and stage of advancement of each country. But it too has to be submitted to the Legislature. The International Labour Organization has no power to compel any country to ratify any draft convention, or to accept any recommendation. It can, however, appeal to international public opinion and there can be little doubt that by educating and voicing such opinion it will ultimately effect a considerable improvement in labour conditions throughout the world.

Hours of Working

Reverting now to the draft conventions and recommendations relating to agriculture detailed above, it should be mentioned at the outset that the Geneva Conference was compelled to delete from its agenda the item relating to the regulation of the hours of work. This was due largely to the opposition of the French Government, who were strongly supported by the Swiss. The French Government had also objected to the inclusion of the other agricultural items on the agenda, but they were unsuccessful in their attempt to show that the Conference had no authority to deal with such matters and that, in any case, it was inexpedient that it should do so. Accordingly among the other agricultural items the question of the prevention of unemployment in agriculture came up for discussion and a comprehensive recommendation containing many practical suggestions was passed.

At Washington draft conventions had also been passed relating to (1) the employment of women before and after child birth; (2) the employment of women during the night; (3) the minimum age of admission of children to industrial employment; (4) the night work of young persons employed in industry. All these points were again raised at Geneva with special reference to agricultural workers, but owing to the difficulties already mentioned, the Conference had to be content with recommendation only, except in the case of the minimum age of admission, where a draft convention was passed.

Maternity Benefit

The question of granting maternity benefit to women agricultural wage-earners aroused much interest. The difficulties in the way of raising sufficient funds, and of administering them were scarcely given any weight and a recommendation was passed urging members "to take measures to ensure to women wage-earners the right to a period of absence from work before and after child-birth, and to a grant of a benefit during the said period, provided either out of public funds, or by means of a system of insurance." Most countries have found it impossible to ratify the Washington convention passed for a similar purpose for industrial workers, where the numbers affected are much smaller. India was not called upon to ratify it, but to make an enquiry into existing conditions. This was done and a report submitted which was laid before the Geneva Labour Conference. The report was favourably received as it clearly indicated that so far as women Government employees were concerned, that the Government of India, and provincial Governments were willing to fall into line. The attempt to enlist the sympathy of employers and to organize further enquiries was recognized as showing clearly the sympathetic attitude of the Government to these proposals.

The prohibition of the employment of women and young persons at night was found to be impractical as far as agriculture was concerned. Two recommendations, however, were passed to ensure a period of rest of not less than nine hours for women and young persons between the ages of 14 and 18, while children under fourteen were to have not less than 10 hours. Those acquainted with agricultural conditions out here will realize how extremely difficult it would be to enforce these recommendations. As a statement of the physical needs of workers they deserve the respectful consideration of employers.

The draft convention concerning the age for admission of children to employment in agriculture is based on the assumption of a compulsory educational system. As compulsion does not yet prevail in India, it is inapplicable here. The draft convention relating to workmen's compensation and the recommendations concerning social insurance against sickness, invalidity, and old age are also at present outside the range of practical politics in India. Similarly, the recommendation relatting to living-in conditions can scarcely have much practical result out here.

The prevention of anthrax and the protection of women and children against lead-poisoning were dealt with at Washington. A further step in advance was taken in both these directions at Geneva. India was more closely affected by the former than by the latter, for if the proposal that was before the Conference, namely, the prohibition of the import of all wool that had not been disinfected were passed, a heavy financial burden would have been thrown immediately on the woollen trade. All wool, whether imported for re-export, or for use and manufacture in this country would have had to be disinfected at the places of entry. India's vast land frontier and the large quantities imported from Indian States makes such a proposition quite impractical.

Largely as a result of the representations made by Mr. Gupta, the Indian Government delegate, it was finally decided that before passing any definite recommendation further enquiry should be made into the economic as well as the humanitarian aspects of the question. For this purpose it was decided that a Committee should be formed consisting of representatives of Britain, France and Germany and the United States, which are the main importing countries, and India, Australia and South Africa, which are among the exporting countries.

White Lead

Discussion on the proposal relating to the prohibition of the use of white-lead in painting aroused much feeling, and it seemed unlikely that any satisfactory solution would be reached.

Dr. Legge, the British Government delegate was, however, largely instrumental in bringing about an agreement. An agreed Draft Convention was drawn up, prohibiting the use of white lead in internal painting and making certain regulations with regard to its use for external painting. Further women and young persons are to be prevented from using paint containing white lead. Much of the immediate utility of these beneficent measures is rendered nugatory by the arrangement that the clauses relating to prohibition are not to take effect for six years.

The draft convention relating to medical examination makes the engagement of a child or young person under 18 conditional, on the production of a medical certificate attesting fitness for such employment, and also arranges that, in the case of continued employment, the child, or young person should be medically examined at least once a year. There should not be much difficulty in adopting this convention in India.

The proposal of a weekly rest day for industrial and commercial workers follows naturally from the attempt made at Washington to introduce an 8 hour day and a 48 hour week. With regard to the former a draft convention was passed, while in the case of the latter a recommendation was accepted whereby "the staff employed in a commercial establishment should enjoy in every period of seven days a period of rest comprising at least 24 consecutive hours."

The Voting

In the discussions that arose Mr. Baldesi, the Italian Workers' delegate, took the opportunity of making two bitter attacks, one on the non-European countries, and one on the procedure of the Conference. The non-European countries, he asserted, had formed a *bloc* "to oppose those measures of social progress which had already been adopted in European countries." The injustice of this accusation was easily demonstrated. Further an analysis of the votes cast at the conference brings out very clearly the interesting fact that the delegates from various countries did not vote jointly as units, but that there was a very strong tendency for the employers delegates to vote together, and for the workers to do the same. The employers sent 24 delegates and the workers 25, the Governments sent 69, which gave them in consequence in a great many cases the casting vote. On the whole the Government delegates from all countries voted consistently on the side of securing to the workers the largest measures of social reform.

The reform of the constitution of the Governing Body of the International Labour Organisation was the subject of prolonged discussions in the Selection Committee, of which Mr. Chatterjee and Mr. Joshi were both members, as well as the most influential delegates, from all the most important countries. The question of reform arose out of the fact that very scanty representation had been accorded to non-European countries on this body. It consists of 24 members who are elected as follows:

(1) 8 members representing the Governments of the eight countries of chief industrial importance.

(2) 4 Government members elected by the countries other than the eight which fall into the first group.

(3) 6 members representing employers, and elected by the employers' delegates.

(4) 6 members representing workers and similarly elected.

As a result of the elections at Washington in 1919, non-European countries only secured 4 out of the 24 places.

In the Selection Committee appointed at Geneva to discuss this point Mr. Chatterjee was able to make out a strong case for the non-European countries, and received very valuable support from Canada and Chile. Finally, a proposal was carried in the Conference, that of the 12 Governments represented on the governing body, 4 should be from overseas countries, and of the 6 employers and of the 6 workers, at least one in each case should be from an oversea country.

In addition to securing a fairer representation of non-European countries, the Geneva Conference passed no less than 7 draft conventions and 8 recommendations on very diverse subjects. This is no small achievement in a meeting which lasted less than a month.

The gathering consisted of 119 delegates from 40 different countries, the delegates accompanied by 236 technical advisers. At a full session, therefore, no less than 355 persons were present, and of these 119 had the right to speak and could abrogate their right in favour of their technical advisers. Each speech had to be delivered in French or English, and where the delegate did not know either of these languages he was permitted to speak in his own language and his speech was then translated into the two official languages. From this fact one can get a conception of some of the difficulties in the way of reaching mutual understanding. At the back of the difference in language lay the greater difference in outlook and temperament arising out of the varied nationalities present. The success of the Conference was due partly to the effective desire on the part of all delegates to achieve definite results, and also in a large measure to the President. Lord Burnham acted throughout in a strictly impartial and judicious manner, but who, at the same time, delivered his rulings with so much urbanity that even the most refractory delegate willingly bowed to them.

India's Influence

India too may well be proud of its achievements at Geneva. It sent an entirely Indian delegation, which secured representation on all the important Committees, in which the detailed business of the Conference was transacted. The Indian representatives were thus able to exercise considerable influence. The fact that India took her place on an equal footing with the other countries of the world, strengthened her claim to be given an active share in the administration of the International Labour Organisation. The views expressed by the Indian representatives always received careful consideration, and the members of the Indian delegation themselves were treated with marked cordiality by the delegates from the other countries, especially from the Dominions. There is still much ignorance about Indian conditions, and affairs even among highly educated persons outside India. Many opportunities naturally arose in so large a gathering for correcting misapprehensions, and for shewing that the great world movement for the betterment of the conditions of workers had not left India untouched. Finally, it may fairly be claimed that the prominent part India is taking in the affairs of the International Labour Organization, has raised her status very considerally in the comity of nations.

First World Power Conference

IT has been the dream of the sage and the soldier, of the philosopher and the prophet to discover some common ground on which man could stand united. They have all failed; but where they have failed, success perhaps may yet be won by the concerted efforts of the scientist, the engineer and the industrial organiser.

In a century Europe has been transformed, socially and industrially, by the discoveries and applications of science. Little more than a hundred years ago, men were as they had been for countless generations, dependent for motive power on the winds of heaven, and the easily fatigued body of man and beast. To-day this force is derived from the Power of Man to direct the physical, chemical, electric and radio-active energies of Nature to his own use.

Without realising it, the nations of the world have become interdependent, international, in their interests, because their very life depends upon the speedy conveyance and handling of commodities vital to their existence.

The essential and varied "needs" of all classes in civilised countries are met by the complicated processes of scientific industry that require raw materials from the ends of the earth. The balance of production and consumption can never again be a matter that concerns merely an isolated nation, or a few; international production must be adjusted to international consumption.

Wars, and particularly the Great War, have upset the balance between world consumption and world production, and consequently the international, financial and economic balance. History has repeated itself by showing that political conferences are as powerless to provide employment, as economic conferences are to revive industry.

Surely it is not unreasonable to say that a Balance of Power amongst nations can be achieved only by the co-operation with statesmen, of engineers, scientists, manufacturers, merchants and financiers, for the interdependence of nations is attributable to science and engineering, to trade and finance.

The industrial centres of the world have much to teach each other. Which is most advantageous—to keep their secrets in the family and guard them for competitive exploitation, or to combine in the technical field, so that their united force may the more rapidly proceed with the conquest of nature? This is a question which a World Power Conference may intelligently answer.

If an international feeling of security can be established, production can be carried on in a friendly competition for excellence and improvement.

Co-operation within national borders has achieved results of which our forefathers never dreamed, in the elimination of waste and the improvement of production, at the same time safeguarding individual enterprise and initiative. Internations co-operation will achieve yet greater results, results stupendous in their effects, and yet more stupendous in their possibilities.

The object of the World Power Conference is to consider how the industrial and scientific sources of Power may be adjusted nationally and internationally. By considering the potential resources of each country in hydro-electric power, oil and minerals; by comparing experiences in the development of scientific agriculture, irrigation and transportation, by land, air and water; by conferences of civil, electrical, mechanical, marine and mining engineers, technical experts and authorities on Scientific and Industrial Research; by consultations of the Consumers of Power and the Manufacturers of the Instruments of Production; by conferences on Technnical Education to review the methods of education in different countries, and to consider means by which existing facilities may be improved; by discussions on the financial and economic aspects of industry nationally and internationally; and lastly by conferences on the possibility of establishing a Permanent World Bureau, for the collection of data, the preparation of Inventories of the World's Resources, and the exchange of industrial and scientific information through appointed representatives in the various countries.

Under the Presidency of the Earl of Derby, the Conference is to be held at the British Empire Exhibition in London, during the summer of 1924. Among the Vice-Presidents, and members of the Grand Council and Scientific and Technical Board are the names of many distinguished gentlemen, some well-known as heads of great industrial organisations, others as leaders in the scientific world.

Arrangements are in progress for the formation of co-operating bodies in the British Dominions, and in other countries of the world.

The British Electrical and Allied Manufacturers' Association is responsible for the promotion of the Conference, and Mr. D. N. Dunlop is the Organising Director.

The Utility of Dissolved Acetylene

The other day we were privileged to attend a luncheon held at the Hotel Cecil in London, and given by Allen-Liversedge, Ltd., for the purpose of drawing attention to the utility of dissolved acetylene. After the luncheon an industrial film was shown to illustrate the possibilities of this "wonder gas." The interested observers had an opportunity of seeing how the gas was made, how the cylinders were filled, the compressing process, and were then shown applications of the "wonder gas" in connection with lighting, lead-burning soldering and sweating, brazing, welding, ship repair work and the cutting of cast iron.

Two illustrations showed a recent development of dissolved acetylene in which it is combined with oxygen for cast-iron cutting, and also the welding of a main mast in a London shipyard by dissolved acetylene combined with oxygen. In order to explain precisely what acetylene is, and what dissolved acetylene will do, Messrs. Allen-Liversedge, Ltd., have published a book entitled "The Romance of Acetylene," written by Mr. Thomas Gaskell Allen, B.A., F.R.G.S., and will be pleased to supply a copy to any interested reader, who applies to the firm at 106, Victoria Street, Westminster, London, S.W.1.

TRANSPORT

Conducted by "M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH THE MANAGEMENT AND CONTROL OF RAILWAYS

Economising M.T. Costs

To keep Motor Vehicle Operating Costs down to a minimum, and to ensure the highest service economy, it is essential most carefully to study the arrangement of Commercial Motor Transport.

IN a recent lecture, Mr. W. H. Gaunt, O.B.E., M.Inst.T., Distribution Manager of Messrs. J. Lyons & Company Limited, the great British catering firm, said:

"The door to door principle is the greatest advantage which the motor has over the railway," and it is upon this text that I propose to base a few general remarks upon the urgent need for economising transport costs in connection with the employment of motor vehicles for commercial purposes.

There can be little doubt that, until quite recent times, insufficient attention has been paid to the avoidance of delays to motor vehicles by the institution of labour-aiding devices which would enable them to "turn round" more quickly, but as was evident from a paper read at a recent meeting of the Institution of Automobile Engineers, the matter is now being viewed from a new and more promising aspect. The paper to which I refer was entitled "Loading and Unloading Devices for Commercial Motor Vehicles," and therein it was pointed out that the standing charges of a 3-ton vehicle, under British conditions, may amount to about 30s. per day. Assuming then, that the mileage covered is 90 per day, the standing charges are responsible for 4d. per mile, and if, owing to terminal delays, the possible mileage is reduced to 60, the standing charges go up to 6d. per mile, representing a constant loss of 2d. per mile. It only needs a simple calculation to show what a relatively large annual waste this would involve. If the yearly mileage is 12,000 per annum, 2d. per mile represents an annual expenditure of £100, which is a sufficiently important item to justify considerable capital expenditure in loading and unloading equipment with a view to its elimination.

The author of the paper to which reference has been made, also said that there was no way in which it was now possible to bring about improvements in road transport efficiency so readily, as by educating the user to an appreciation of the importance of this matter of terminal delays. In very many cases in which results obtained with the first vehicle have been insufficiently good to justify further purchases and the scrapping of horsed vehicles, the comparative failure is directly traceable to lack of organisation for loading and unloading. The main thing is to get the motor user to realise that he is often throwing away at the terminal points far more money than he is saving by the exercise of the greatest possible care and economy in the selection and maintenance of his vehicles, as the expenditure represented by idle time is in most instances immeasurably greater than any saving that can conceivably be made in such items as fuel cost.

Developments by British Railway Companies

There, in two or three sentences, is the indictment, and few of those sufficiently alive to the difficulties would say it is too strong. The trouble is to get motor users to appreciate the real facts of the case. If the motor vehicle is to perform its transport function in the most economical manner, it must not only act reliably under service conditions, but it must be kept from "eating its head off" to no advantage. Thus arises the necessity for the provision of suitable equipment at loading stages, the installation on the chassis itself of adequate lifting tackle, where such can be given profitable use, and the adoption of specially equipped detachable bodies to cut out, or, at least, to minimise very considerably, the time taken in loading and unloading.

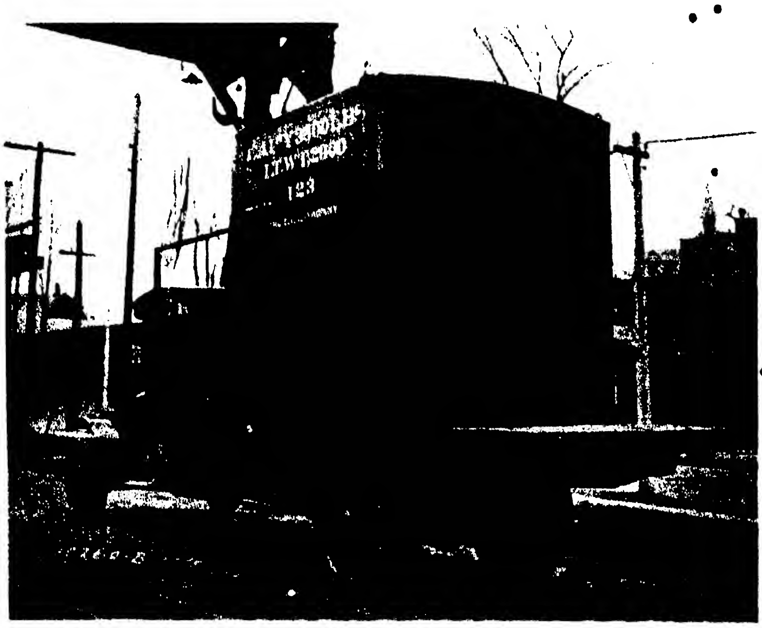
It is a peculiar fact, but nevertheless the truth, that British Railway Companies have probably done more to eliminate wasted motor transport energy than those transport firms who use motor vehicles exclusively. Following up their long-established methods of speeding up the turn-round of wagons, the railway companies have adopted a system of demountable flats, under which it is possible for a load to be transferred in a few minutes. These demountable flats are usually fitted with self-aligning ball-bearings, the use of which facilitates the handling of the flats, especially in their loaded condition.

In this connection the London & South Western Railway Company have done splendid work. Having decided to introduce mechanically-propelled vehicles in lieu of horses for cartage work, they set themselves to the task of cutting out all avoidable waste, and to this end adopted a system in which "demountable flats" and "stands trolleys" are integral parts. These "demountable flats" upon which goods traffic is placed, are adapted to be transferred between the "stand trolleys" and the actual road motors, and this enables the motor vehicles to be kept almost continuously on the move, at least in so far as the railway company is able to control this. The success of

the system is indicated by the fact that the average weight carted per motor per day has been increased from 8 tons 5 cwts. to nearly 11 tons. The motors used, which are of the 2 and 4-ton types, are adapted for the transfer of "demountable flats," and are constructed by John I. Thornycroft & Co. Ltd., and by Karrier Motors Ltd. This is undoubtedly one of the directions in which the ordinary road vehicle owner should move, as for a comparatively small expense he can so widely extend the mobility of his vehicle.

A more recent development is the experimental use by the Great Western Railway, of England, of Fordson tractors for hauling their heavy railway lorries between specified points in London. These tractors are similar to those of the "Fordson" type mentioned in the article on "International Tractor Trials," which appeared in the February and March, 1922, issues of INDUSTRIAL INDIA, except that they are fitted with rubber tyres, and their use has been found to give substantial advantages. While the ordinary lorries are being unloaded or loaded at the terminals, the "Mechanical Horse" as the tractor has aptly been called is doing useful continuous work between the terminals, and in daily practice it is averaging 56 miles, and hauling 16 tons 10 cwt. of traffic, the conveyance of which in the same time would, under ordinary conditions require two pair-horsed vehicles. Of course, certain classes of conveyance work are required for the most effective development of this system, but it is an innovation that should be kept well in mind in contemplating cartage economies. As will be noted, this method has many of the advantages of the "demountable flat" system, without the necessity for additional machinery on the road vehicles themselves.

Of a similar character is the growing use of containers, and especially in America, these have been adopted extensively. There, in fact, they have developed the use of containers on a most comprehensive basis, as was described in the article entitled "The Container Car on the American Railways" which I contributed to the May, 1922, issue of INDUSTRIAL INDIA. The container system provides that a portable container (or box) shall be loaded and locked at the consignor's own loading stage, conveyed by motor vehicle to the railway yard, and there speedily lifted by crane aboard the container car, where steel bulkheads and sides form absolute protection against opening the container in transit. On arrival at destination, the locked container is unloaded by crane and carried by motor vehicle direct to the warehouse or consignee's loading stage, to be unloaded at his convenience. The type of container used for L.C.L. (less than carload), freight is shown in one of the accompanying illustrations, which shows a road motor transport company's vehicle leaving the railway yard with a loaded container for the consignee.



Motor Vehicle leaving Railway Yard with Loaded Container

The Reduction of "Terminal" and "Intermediate" Delays

The foregoing remarks indicate two recent methods introduced in the endeavour to reduce terminal delays, and it may now be well to analyse motor vehicle delays, both terminal and intermediate. These may be divided into three sections, so far as the solution of the problem is concerned.

Firstly, the provision of specially equipped bodies facilitating the rapid handling of loads in detail, or the provision of detachable bodies with suitable mechanism to enable them to be rapidly run on or off the chassis. Second, the provision of special equipment at the motor user's premises, as, for example, cranes, ramps or runways at the loading stage. Third, the special equipment of the chassis itself, as for example, the fitting of gear for operating a tipping body, an overhead crane for loading purposes, or a winch operated by the engine power.

It is in these directions that development must tend if the motor vehicle is to find its most economic use. The question of expense is, of course, a consideration, and one that must always be borne in mind. But judicious expenditure designed to increase the mobility of a motor vehicle will very soon pay for itself, and if the desire for improvement is sufficiently strong, the question of expense should not prove insurmountable. One way in which there might be a great move towards efficiency is for motor vehicle manufacturers themselves to study the problem, with a keener eye to the requirements of the traffic, for this is quite as important a matter as the enhancement of the reliability of their product.

Are Commercial Motors Too Heavy?

It is a constant and growing complaint against many classes of commercial motor vehicles that they are relatively heavy for the work they are designed to perform, and this point has recently been stressed very strongly in articles written by the Commercial Motor Correspondent of *The Times*. He explains, in defence of the makers, that the manufacturers

have been driven to this undesirable course by reason of the unfair handling of their vehicles by motor users, and in two excellent articles on "Loads and Loading" he deals very clearly with the problem of effecting economy in haulage costs. Commercial motor users have, he says, no one but themselves to blame for the relatively heavy vehicles now being built. If they persist in overloading their vehicles, the natural result is high maintenance costs and the consequent suggestion that the vehicles are not standing up to their work. Thus arises the need for the manufacturers, in self defence, to build the vehicles with a larger margin of safety, and one can quite see the force of their attitude in the matter.

A Good Load (seven tons of timber) on a 4-ton Leyland Motor and Trailer

At the same time, if motor transport is to develop as widely as is anticipated, it is of the utmost importance that commercial vehicles shall be of as light a character as possible, consistent with their ability to perform properly the work for which they are *designed*, and it is therefore suggested that motor users should see to it that overloading is discountenanced. It is directly to their interest to do this, because, in the long run, if adequate records are maintained, it will be found that a properly handled vehicle of a particular design will work more cheaply than another of a similar type that has been subject to consistent overloading. As *The Times* well puts it, a chassis is designed for a given load, and if the limit is passed often and considerably, the additional stress caused to the mechanism throughout will result in deformation, shear and undue wear generally. What is the result? The ton-mile cost of a vehicle during a short period of overloading may perhaps have been reduced fractionally, but after that it may have to go in dock where expense is incurred, the standing charges remain and the vehicle is earning nothing. In other words, at the end of a period it may be found that the service cost is higher and the ton-mile figure lower than if overloading had been avoided and the vehicle kept in steady work.

An essential need toward securing the utmost economy in running costs is the maintenance of regular comparable operating costs, and those firms keeping detailed records are satisfied that they more than pay for the expense of compilation. In too many cases has the question of motor transport been looked at from the standpoint of horse haulage, and so long as the motor appears to be a cheaper transport medium nothing else has mattered. But this is a foolish policy. Under adequate supervision, a commercial motor service can be arranged to give extremely satisfactory results, but the quesiton must be handled in a scientific manner, and not worked on the "rule-of-thumb" methods that in far too many cases do justice for system. In a later article I propose to analyse a series of cost figures, and show how the maintenance of appropriate records has assisted to secure economy in haulage costs.

WILL INDIAN TRANSPORTATION BE CO-ORDINATED?

The first "Transport" article in the first issue of INDUSTRIAL INDIA dealt on a comprehensive basis with the question of agriculture and industry in India, and pointed out how development in connection therewith was closely bound up with the provision of abundant transport facilities. The article concluded with a suggestion that Indian agriculture and industry would benefit materially if the whole of Indian transportation were placed in the hands of a small representative body . . . as the railway, the inland waterway and the air should all be considered with regard to their comparative economy in connection with future development. This idea, it is well to recall, was closely followed up by the Acworth Committee which, being satisfied that the member for Commerce could not adequately attend to railway matters, recommended the addition to the Governor-General's Council of a member for Communications. This member was to be responsible for railways, ports, inland navigation, road transport, posts and telegraphs, and he would therefore be in a position to effect any necessary co-ordination between the different—and often complimentary—means of communication.

At the time of writing, we still await any news as to the acceptance or otherwise of this suggestion. Along with many other matters brought out in the Acworth Report, the suggsstion appears to have been pigeon-holed, and it would not be unfair to suggest that in a few years time still another Commission will be appointed and requested to "straighten out" what the Acworth Committee has so admirably reported upon. If there is the need in any country for the co-ordination of all means of communication—or, at least, of transportation—that need exists in a newly developed country, which is trying to expand its trade and industry. India has suffered sadly for want of adequate foresight in the past, and the scandalous state of affairs brought to light in the Acworth Report is sufficient proof, if proof be needed, of the need for some drastic re-arrangements of overhead control.

The Freight Locomotives for the Chilean State Railways

Following the description of the Passenger Locomotives given in our September issue, we give below some details of the Freight Loco's to be used.

THE cabs for the first eight of the fifteen road freight locomotives for the Chilean State Railways, have been delivered by the Baldwin Locomotive Works to the Westinghouse Electric & Manufacturing Company for the installation of the equipment. There will also be seven switching locomotives.

The cab of the road locomotive is of the box type, carried on two articulated trucks, each having three driving axles with direct geared motors. The estimated weight is 226,000 pounds. The locomotives will operate at 3,000 volts direct current.

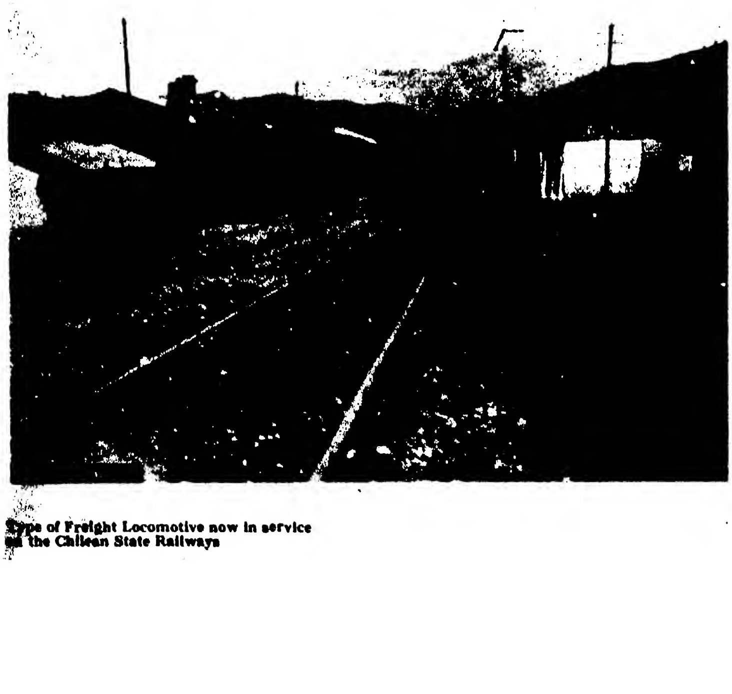
This locomotive rates 1,680 h.p. at 3,000 volts, and will be able to develop a maximum of 3,200 h.p. for short periods. With natural ventilation the locomotive will deliver for one hour a tractive effort of 27,950 pounds at a speed of 22.6 miles per hour at 3,000 volts. The continuous capacity of the locomotive with forced ventilation is 20,880 pounds tractive effort at 24.8 miles per hour. The maximum speed is 40 miles per hour.

The general dimensions and estimated weights of the locomotive are as follows :—

TABLE I.

DIMENSIONS AND WEIGHTS OF ROAD FREIGHT LOCOMOTIVES.

Track gauge	5' 6"
Length over buffers	49' 10"
Length over cab	38' 0"
Total wheel base	37' 0"
Rigid wheel base	13' 9"
Height top of rail to cab roof	12' 7"
Height top of rail to clerestory	13' 10"
Width over cab sheets ...	10' 0"
Height of coupler	41"
Wheel diameter	42"
Weight of complete locomotive	226,000 lb.
Weight of mechanical parts	140,000 lb.
Weight of electrical equipment	86,000 lb.
Weight per driving axle	37,670 lb.



Type of Freight Locomotive now in service on the Chilean State Railways

The road locomotives will operate over the 116 mile route between Santiago and Valparaiso, and the 28 mile branch between Las Vegas and Los Andes. The heaviest grade is 225 per cent. for 12 miles, from Llai Llai to La Cumbre. The maximum curvature is 11 degrees. There are six tunnels in the electrified zone.

The present main line freight trains average 550 short tons. They are operated with a single steam locomotive, except on the heavy 12 mile grade southbound, and on a northbound grade, of 6.8 miles. On these two sections a steam helper is now used to maintain speeds of from 10 to 14 miles per hour.

One electric locomotive will haul a trailing load of 770 short tons in either direction, between Valparaiso and Santiago without assistance, except on the Tabon grade. On level tangent track the speed with such a load will be 35 miles an hour at 3,000 volts. The average running speed on the Tabon grade will be approximately 24 miles per hour. The time saved by the elimination of delay to take fuel and water, and by the higher running speed will shorten the time of a trip from 4 to 5 hours in each direction.

These locomotives are equipped with Continental spring buffers, and M.C.B. couplers, arranged to take attachments for chain couplers temporarily. The two six-wheel trucks are connected at the inner ends by a mallet hinge. The bar-type cast steel side frames are located outside of the wheels and connected by cast steel bumpers and cross-ties. The semi-elliptic driving springs over the journal boxes on each side are connected to one another by equal beams. The ends of each set of three driving springs connected thus are attached to the side frames through coil springs.

The 38 foot box type cab, including an engineman's compartment in each end and a central equipment compartment, is carried on centre pins located approximately over the mid-

point of each rigid wheel base. One centre pin is restrained both longitudinally and laterally and the other in the lateral direction only, which permits free longitudinal movement of the cab relative to one truck.

The locomotives are equipped with Westinghouse air brakes, the standard of the Chilean Railways. The air brake, type 14-EL is interlocked with the regenerative brake so that the latter may be supplemented by service application of the train brakes, if desired, without applying the air brake to the locomotive drivers.

Current is collected by spring-raised, air-lowered pantagraphs, controlled by compressed air and arranged to be mechanically locked in the lowered position.

Individual switches mounted in banks establish the main circuit connections. Each switch is a complete unit in itself, and may be removed without disturbing adjacent switches. Compressed air controlled by electro-magnetic valves is used to operate the switches. For certain circuits where no current is broken and for low voltages, cam switches are used. These also operate by compressed air controlled by electro-magnetic valves. The cam group comprises a number of switches mounted on a single shaft, connected through a rack and pinion to a double acting air piston.

Each axle of the locomotive is driven by a Westinghouse No. 350-D motor, wound for 1,500 volts, and insulated to operate two in series on 3,000 volts. The nominal rating of this motor on short field is 280 h.p. at 155 amperes and 1,500 volts. Field control is secured by the use of two separate field windings on the main poles. The motors are geared directly to the axles with a ratio of 3.94 to 1. The gear is of the flexible type.

A motor generator set provides low voltage power to compressors, blowers, control equipment and lights. This set has a single frame and two armatures carried by a common shaft. The 3,000 volt motor is a bi-polar double-commutator machine. The continuous rating of the generator is 35 kw. at 92 volts.

A master controller is located in each engineman's compartment to provide double end operation, the same master controller being used for both motoring and regenerative braking. This controller provides 50 control notches in acceleration so that tractive effort variations are small, thereby permitting exceedingly smooth handling of trains.

The control is Westinghouse HLFR providing speed combinations by varying the grouping of the motors to give one-third, two-thirds, and full speed. Field control gives three additional speeds. Transition from one motor combination to another is made by the shunting method.

For regenerative braking, the main motor armatures are arranged for the same combinations as when motoring, and the motor fields are separately excited by the motor-generator set. The range of speed in regenerative braking will be from 8 to 30 miles per hour.

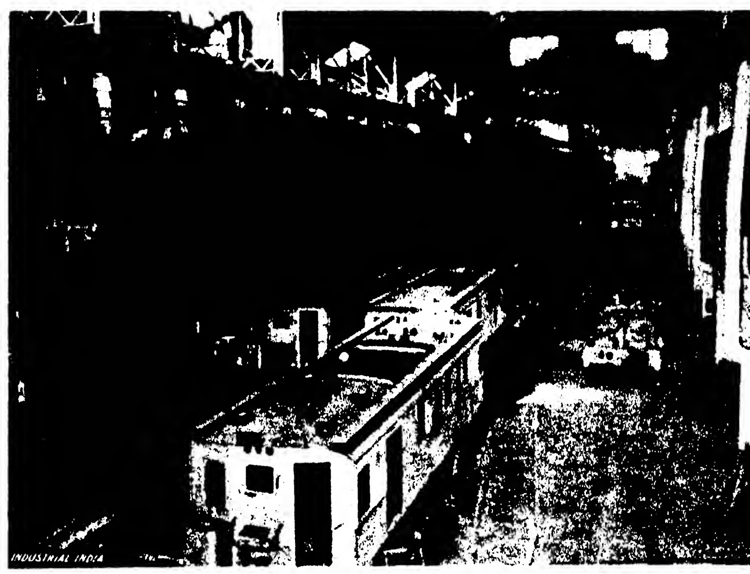
The cab of the switching locomotives is of the steeple type, and is carried on two swivel trucks. On each truck are mounted two motors,

The following table gives the general dimensions and estimated weights of the locomotive :—

TABLE II.

DIMENSIONS AND WEIGHTS OF SWITCHING LOCOMOTIVES.

Track gauge	5′	6″
Length over buffers	40′	0″
Length over central cab ...	17′	0″
Length over hoods	27′	0″
Total wheel base	27′	4″
Rigid wheel base	8′	6″
Height—top of rail to cab roof	12′	3″
Width over cab sheets ...	10′	0″
Height of coupler	36′	0 1/16″
Wheel diameter		42″
Weight of complete locomotive	130,000 lb.	
Weight of mechanical parts	80,000 lb.	
Weight of electrical equipment	50,000 lb.	
Weight per driving axle ...	34,000 lb.	



The Locos under construction at Westinghouse Works

driving direct through standard helical gears. The estimated weight is 136,000 pounds. The control is arranged for double end operation.

The nominal rating of this locomotive is 560 h.p. With 3,000 volts, and natural ventilation, the tractive effort for one hour is 19,600 pounds, at a speed of 10.6 miles per hour, and the continuous capacity is 11,400 pounds at 12.7 miles per hour. With 25 per cent. nominal adhesion the starting tractive effort is 34,000 pounds. The maximum speed is 35 miles per hour. For short periods the equipment is capable of developing 1,000 h.p. In view of an expected increase in traffic these locomotives will be capable of handling trains of 1,200 short tons in yards with level tracks.

The trucks are of the rigid bolster equalized type, with rolled steel frames located outside of the wheels. A centre pin is located at approximately mid-length of each rigid wheel base. The central cab has an engineman's stand in each end and control apparatus centrally located and suitably protected. Buffers, couplers and air brake equipment are duplicates of those on the road locomotive. The control equipment also comprises apparatus similar to that already described for the road locomotives, and the pantagraph is of the same type.

The four Westinghouse No. 350-D-2 motors are of the series type wound for 1,500 volts and insulated for operation two in series at 3,000 volts.

This motor has an hour rating of 140 h.p. at 75 amperes and 1,500 volts.

The motor generator set, to supply power for the compressor motor, lights and control circuits, has a two part frame, each part containing two bearings in which runs a common shaft carrying two armatures, one a 1,500 volt motor (insulated for 3,000 volts), and the other a low voltage generator. With 3,000 volts applied to the motors, the generators will deliver 22.5 kw. at 92 volts.

The main resistance, connected ahead of all motors, is designed with ample capacity for frequent, heavy accelerations, and for a reasonable amount of emergency operation with one pair of motors cut out. The number of accelerating steps assures moderate changes in tractive effort in starting, which in turn tends to minimum wear and tear on the locomotive and rolling stock.

The passenger locomotives for this electrification were described in our September issue.

The Need of an All-India Gauge Policy

In the September issue of "Industrial India," we published the first part of Mr. Royal-Dawson's paper, which was read before the Indian Section of the Royal Society of Arts. We now publised the remainder of this instructive paper which is worthy of the close study of all those concerned with India's transport developments.

I WILL deal first with the evils of the break of gauge, which are the inevitable results of the dual system.

Formerly it was assumed that the inconvenience of a break of gauge was confined to the actual handling charges of transhipment, the amount being equivalent to a few miles (say, 10 or 20 miles) of extra haulage. We now know by bitter experience that that is the least important factor of the situation. The main evil lies in the serious detention to rolling stock at every point of transhipment, amounting to at least a day, and sometimes several days, for every train concerned. This means incalculable delays in transit and the corresponding waste of locked-up capital, not only in rolling stock, but also in the goods carried. A certain agent of the Eastern Bengal Railway, which has both gauges in its system, estimated that from a railway point of view alone it would pay to spend Rs. 20 lakhs of capital outlay (equivalent to, say, £133,000—but this figure does not pretend to be exact), to avoid the transhipment of one broad gauge train a day. Again, every transhipment point is a fruitful source of damage and loss by theft of goods in transit, especially at important junctions, where transhipment on a large scale takes place. The Indian public, who have been brought up to regard this state of affairs as inevitable, do not appear to realise what a difference uniformity of gauge would make in the efficiency of railway transport and the development of trade generally. The evils of a break of gauge cannot be exaggerated, for, with the co-expansion of the two gauges, they increase with the increase of tonnage transhipped.

As to whether wholesale transhipment at a big junction is preferable to transhipment at several scattered points for the same aggregate tonnage much depends on circumstances. In theory it may seem more convenient and economical to tranship 10,000 tons at one big junction instead of at a dozen scattered small ones. But in practice the worst congestions occur at big junctions, whereas, if all main lines were of uniform gauge and the only transhipment points occurred at wayside stations where local feeder lines of a different gauge joined the main line, all transhipments would be of a local character and would be done by local station staffs, more or less under the observation of consignor or consignee, as the case might be, and, therefore, subject to less risk of mishandling or unaccountable delays or loss in transit. So far as the consignor or consignee are concerned, therefore, there is no doubt that the least objectionable position for a transhipment is near the beginning or end of a journey, as in the case of a wayside station, served by a local feeder line, the latter being merely a substitute for local road transport.

From the administrative point of view the supply and movement of wagons is the chief difficulty, especially as between two administrations where exact synchronisation of supply at transhipment points is almost impossible of attainment.

Movement of Wagons

Even railways which have the two gauges under one administration (such as the Bombay-Baroda, the South Indian and the Eastern Bengal), and which should, therefore, be able to insure the co-operation of both gauges in the punctual and adequate supply of wagons at transhipment points, find this process a perpetual source of anxiety and liable to break-downs at critical moments. The following extract from a report by Mr. Waring, who was deputed by the Ceylon Government to report on Indian Railways in 1895, is sufficient to illustrate the position, Sabarmati being a goods transhipment yard near Ahmedabad on the Bombay-Baroda line :—

"It has often been said that, with proper management, a block or serious delay of traffic at a transfer station should never occur. To this I have only to reply that at Sabarmati, the junction between

INDIAN RAILWAY GAUGES.

Fig 1.

the Rajputana-Malwa (metre gauge) and the Bombay-Baroda and Central India (standard gauge) Railways which, it is to be noticed, are both under the same management, such blocks of traffic are, I understand, by no means unknown. The first result of such a block is that the sidings at the transfer station are choked with laden vehicles, the contents of which cannot be transhipped at sufficient speed; all available sidings at the neighbouring stations then become similarly choked with vehicles, the goods stations throughout the line become choked with traffic, which cannot be despatched owing to the insufficient supply of wagons, and then the mischief extends in both directions, causing complete dislocation of all traffic arrangements, until by the most strenuous efforts the block of wagons at the transfer stations are removed. If this state of affairs can occur when the two railways are under the same management, it is evident that it is still more likely to happen when the lines are under different ownership."

Although the above report was written in 1895, it is equally applicable to railways in general at the present day. In fact, so far from showing an improvement, the present position has become worse with the general growth of traffic. The general public who become aware of a difficulty in supplying wagons, but who do not know the cause, assume that the railways are not sufficiently equipped with rolling stock, and set up a clamour for more wagons. Whereas it is evident from the above description that what is required is not necessarily more wagons but a greater synchronisation of movement between the two gauges, hardly attainable under the most careful management, and therefore irremediable under the dual gauge system.

Terminal Facilities

It may be said that blocks occur even on railways of the same gauge. That is true, and the remedy for that is greater terminal and junction facilities. But while reforms are needed in this direction also, the railway system as a whole can never be made an efficient transportation machine so long as the greatest evil of all, namely, break of gauge, is tolerated.

Even if we look at the least important factor in transhipment, namely, the actual handling charges, equivalent to say 10 or 20 miles of extra haulage, at every transhipment station for every ton transhipped the question arises, why should trade be handicapped by such an extra charge *in perpetuo*, if a uniform gauge is a practicable proposition to any degree?

The above considerations are, I hope, sufficient to furnish a reply to the first point at issue, namely, that the perpetuation of the dual gauge is *not* to the public interest.

The Gauge Dilemma

Before proceeding to the second point at issue, the difficulties of the situation must be considered. Unfortunately the gauge problem appears to have been studied hitherto almost entirely from a purely railway point of view. To a railway administration a break of gauge is a nuisance to the extent that, besides holding up wagons unnecessarily, it involves the perpetual task of arranging for the transfer of consignments from one gauge to another. But from a dividend point of view railways do not appear to suffer much by these inconveniences. So long as they can carry in their own time all traffic offering itself in the course of the year, without guarantees as to date of despatch or time of transit, their obligations to the public are, I believe, legally fulfilled and their earnings are more or less assured. It is probably for that reason, and in the absence of an enlightened public opinion, that railways have hitherto made no real attempt to initiate a unification scheme.

I do not make this suggestion in disparagement of railway administration, I merely put it as a possible psychological explanation of the existing state of affairs.

Possibly the reason that the recommendations of 1889 were never acted up to was because they did not carry sufficient conviction in the face of vested interests at that time, and possibly because there was no public opinion on the subject. Moreover, the subject was not so well understood then as it is now. In the circumstances it is not unnatural that the metre gauge, being the minor gauge, would strain every nerve to secure what it believed to be vital to its own interests, and the present day map shows that its achievements have been considerable and its potentialities very great. Its most noteworthy achievement, in the tactical sense, was perhaps the Cawnpore-Barhwal link, already referred to. The material success of this link from the metre gauge point of view has rather tended to obscure its objection on more general grounds. It may be supposed that its inception was due to the theory that trade would be fostered between the metre gauge regions of the Bengal and North-Western and the Rajputana-Malwa by connecting them with a metre gauge link. This theory, confirmed by results, clearly demonstrates what a deterrent effect the previous break of gauge must have had on the flow of traffic interchanged between the two areas. Nowadays, however, defenders of the dual gauge are prone to argue that the evils of the break of gauge are insignificant. But we cannot have it both ways. If the latter hypothesis is true, then the Cawnpore-Barhwal link was an unnecessary expense. On the other hand, if the evils of break of gauge are admitted, then the true remedy would appear to be, not connecting links to maintain the minor gauge, but conversion of the minor to the standard gauge as traffic develops, in order to remove the need for transhipment. These are the sort of reflections that the existence of the Cawnpore-Barhwal link will always give rise to, unless the link is regarded merely as a temporary stop-gap, fulfilling a useful purpose at a certain stage of the evolution of railway traffic, pending final conversion.

An Interesting Example

Another example of the influence of gauge on the trend of traffic occurs in the case of the Fazilka-Kotkapura-Bhatinda branch of the Rajputana-Malwa metre gauge railway, which is worked by the Bombay-Baroda administration. This branch, about 77 miles long, of which Fazilka-Kotkapura is about 50 miles, was in existence before the broad gauge railways which immediately surround it were constructed. Consequently the traditional port for Fazilka traffic is Bombay, although the nearest port by rail has, for many years, been Karachi. The latest broad gauge line is that connecting with Fazilka on the west side, and it is significant that since the construction of this line the proportionate flow of traffic from the Fazilka - Kotkapura section for Karachi, as compared with that for Bombay, has been slowly but perceptibly increasing, in spite of the

break of gauge at Fazilka. The inference is that traffic from this region would always have been for Karachi, in preference to Bombay, if it had not been for the metre gauge offering the least line of resistance for so many years. It would therefore be obviously to the public interest to convert this section to the broad gauge (thereby, incidentally, saving the redundant Kotkapura-Bhatinda link, 27 miles long, which would go a long way towards paying for the conversion, even though the interests of the Bombay-Baroda administration might thereby be slightly affected.

Suggested Remedial Measures

I now proceed to formulate my proposed measures to alleviate the evils of the dual gauge. They are based on the natural growth of traffic on every railway. When the traffic begins to exceed the capacity of a single line, the railway is faced with the alternative of doubling or conversion to a wider guage. In the case of the metre gauge the cost of conversion to broad gauge is, generally speaking, rather less than that of doubling, while the immediate effect of conversion is to double the capacity of the track. The point to note is that all railways must incur additional capital expenditure from time to time to meet the natural growth of traffic, so that, if it became a recognised rule that the metre gauge railways, which, as already noted, are still practically all single track, should be converted to broad gauge in preference to doubling as soon as their traffic exceeded the capacity of a single track, the metre guage would be automatically eliminated in course of time, practically without incurring any expenditure beyond that which would have to be incurred in any case to meet the growth of traffic. So much for existing metre gauge lines. An exception might be made in the case of Burma and the Assam-Bengal railway, which being more or less isolated from the general railway system of India, could be left out of the conversion scheme for an indefinite period without detriment to public interests. Other metre gauge areas would also be left undisturbed so long as the traffic was insufficient to justify conversion.

The construction of new lines on the metre gauge would have to be restricted by legislation in such a way as not to further prejudice the position.

To meet the objections of those who argue that the poorer and undeveloped districts of India would not yield sufficient traffic to make a new broad guage line pay its way, I propose that 2 ft. 6 ins. and 2 ft. feeder lines be permitted as at present, on the understanding that such lines be converted to broad gauge as soon as the growth of traffic is sufficient to justify the cost of conversion.

The above are the three salient features of a policy which, if carried out intelligently and consistently, would rid India, in course of time, of the curse of the dual gauge without involving more expenditure, practically, than that required to meet the natural growth of traffic.

In considering the practicability of carrying out such a policy, it should be noted that the principal railways of India are state-owned, of which three are also state-managed, the remainder being company worked on such terms that Government gets by far the greater share of the profits as the predominant partner. Moreover, the present time is specially favourable for considering the question, for the recent five years' programme, drawn up by the Railway Board, shows that all available money for the next five years will be required for the rehabilitation of existing lines, so that the construction of new lines will be practically suspended during that period.

Opposition Factors

Of course, it is to be expected that each feature of the proposed scheme would have its opponents. For instance, it has been urged that the conversion of the main line of the Bengal and North Western would involve the creation of about thirteen transhipment points at the junctions of its main line with branches, unless the latter were converted too. Against this may be set the fact that at least a dozen existing transhipment points with other gauges would be wiped out automatically by such conversion, not to mention the credit obtained from the dismantling of the existing 80 mile Cawnpore-Barhwal link, which would by this scheme automatically cease to serve any purpose. As between the dozen or so local transhipment points which would be created by conversion and the existing dozen inter-railway junction transhipment points which are now necessary, there is no doubt that the public would prefer the former alternative if for no other reason than that such points would be nearer the consignor or consignee, as the case might be. Moreover, on general grounds, the aggregate tonnage which would be transhipped between branches and main lines would presumably be less than the aggregate tonnage of main line and branches combined to be transhipped to other railways and vice versa, so that such a move would be a distinct step towards mitigating the evils of break of gauge. As regards dividends, there is no reason whatever to suppose that dividends would be adversely affected by conversion, any more than they would by doubling. It is to be borne in mind that my proposals do not involve the conversion of a single metre gauge line before the traffic reaches the limit when the choice between doubling and conversion is forced on the railway. On the other hand, I do not believe that there is a single metre gauge railway that would not benefit by conversion when the time came. It is an established fact, though not sufficiently recognised, that the working of the metre gauge is inherently less economical than that of the broad gauge; that is to say, for a given volume of traffic in a given tract of country, and under a given administration, the cost per ton-mile or per passenger-mile, would be less on a broad gauge railway than on an equivalent metre gauge line. As regards capital cost, we have already seen that the cost of a railway depends more on the volume of traffic than on the gauge. The only conditions under which the gauge is an appreciable factor of first cost is (1) when the traffic is very light, and (2) when the country is very easy, especially when the track is allowed to be laid on an existing public road. This is shown clearly in the diagram (Fig. 2) which illustrated my paper to the Institution of Civil Engineers and which is here reproduced by permission of the Council of the Institution. In such circumstances, a 2 ft. 6 in. line would be obviously cheaper than a metre gauge at first cost, while it would be capable of meeting a growth of traffic by the provision of additional rolling stock and other facilities, from time to time, until the volume of traffic attained sufficient proportions to justify conversion to broad gauge. Thus the whole of the traffic of India could, in course of time, be worked by the broad gauge,

supplemented by narrow gauge (2 ft. 6 in. or 2 ft. 0 in.), feeder lines, so that the use of an intermediate gauge, such as the metre, would be superfluous.

Against the contention that capital cost depends more on volume of traffic than on the gauge, it is sometimes pointed out that the sharp curves which are possible with the narrow gauge as compared with the broad make a great difference in the cost of earthwork, as between the gauges in mountainous country. My reply is that such reasoning would apply only to certain mountain railways, which, being always of a special character, hardly come within the scope of the gauge problem. The majority of narrow gauge lines are laid in very easy country, so that the sharpness of the curves used has no material effect on the cost, as compared with other factors.

As regards the proposed restrictions on the construction of new metre gauge lines by legislation, I believe legislation to be necessary as the only way to secure continuity of policy in the direction of unification, which is what is badly wanted.

To this end I proposed, in my paper to the Institution of Civil Engineers, that the Indian Railway Act be amended and enlarged so as to include a section dealing with the gauge question, the provisions of the section to be somewhat as follows :—

(1) This section of the Act shall apply to all parts of India, except Burma and Assam.

(2) The 5 ft. 6 in. gauge shall be the standard gauge.

(3) Any railways or portions of railways under the operation of this section of the Act not conforming with such standard gauge shall be converted to that gauge when, in the opinion of the Governor-General in Council, such conversion is required in the public interests.

(4) The construction of all new railways shall be on the standard gauge, except as may hereinafter be provided.

(5) Subject to the operation of Clause 3 :—

(A) Lines of light traffic, when cheapness of first cost is an important consideration, may be constructed on the 2 ft. 6 in. gauge, or on the 2 ft. gauge in case of extension of existing 2 ft. lines.

(B) A new line may be constructed on the metre gauge only on the following conditions :

(i) that it is an extension of an existing metre gauge line ;

(ii) that it does not connect with or cross over a standard gauge line.

N.B. Under this sub-head, connection means the provision of direct tranship arrangements.

Before leaving the subject of legislation, I may recall the fact that the present uniformity of gauge in the United Kingdom is due to the timely legislation of the forties, and that the confusion of gauges which exists in Australia, South America and other countries, is due to the absence of such legislation in those countries.

It may be said that the above measures would not be sufficiently elastic, but I am of opinion that, taken as a whole, such a policy would be infinitely more satisfactory than the present opportunist formula of treating every case on its supposed merits, without reference to any recognised guiding policy, by which gauge questions are settled under present circumstances.

I will conclude by saying that I fully appreciate the merits of the metre gauge, but the point is that it is too good for a mere supplementary gauge. Its virtues are the strongest arguments against its retention. For as long as it exists it will strive to extend its activities in competitive areas, and thus aggravate the evils of the dual gauge to the hindrance of real progress in transport efficiency and commercial interests as a whole. If unchecked it will lead to an expensive struggle in which the broad gauge must ultimately prevail, because, as I pointed out in my paper to the Institute of Civil Engineers—

(*a*) The capital sunk in it is already more than double that of the metre gauge.

(*b*) It now carries 80 per cent. of the total railway tonnage of India at remunerative rates.

(*c*) It is inherently more economical in working than the metre gauge.

(*d*) It has higher potential speeds than the metre gauge.

(*e*) It is susceptible of indefinite expansion.

My proposed legislation, therefore, aims at attaining by peaceful and economical methods the ultimate removal of an incubus in railway transport in India, in the shape of the dual gauge, which it seems hardly fair, either on moral or economic grounds, to inflict on posterity.

RECLAMATION WORKS AT BOMBAY

An interesting article in the *Times Trade Supplement* (Engineering Section) for June 17, which is illustrated by photographs taken by Sir George Buchanan, reports that in connection with the reclamation, under the Bombay development scheme, of 1,200 acres of Back Bay, some 2,000 feet of wall have been constructed at each end. Particulars are given of the drilling apparatus in use in the quarry, these comprising heavy rock drills, and jackhammer sinkers, the lifting and crushing plant, the transport arrangements and the water supply. It is pointed out that the work on the sea wall will extend over six working seasons, and so will not be completed until 1929. The wall, as designed, will be of 16 ft. width, and consist of a mass concrete upper wall with parapet, resting on a rubble moundbase deposited on the bed of the bay. Timber gantries carrying two lines of standard gauge railway have been built at each end. In addition to the sea wall, the cross bunds and the railway embankments across the foreshore require large quantities of stone for their execution, and an interesting note claims that the work of quarrying at Akurli Hill, near the Kandivlee station of the B.B. and C.I. Railway, is being carried out on a scientific and labour-saving basis, probably not approached in efficiency by anything else in Asia.

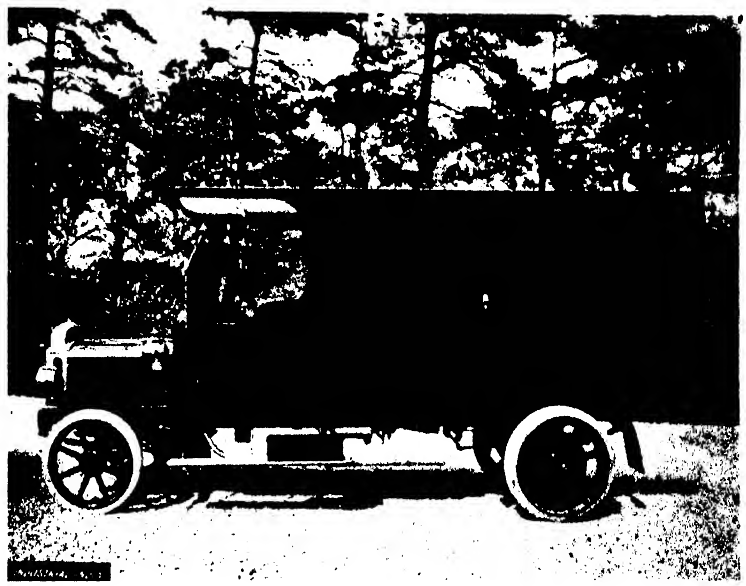
Recent Productions

The following notes give some details of recent Road Transport Vehicles, including an interesting lorry attachment

Useful Passenger Motor Vehicles

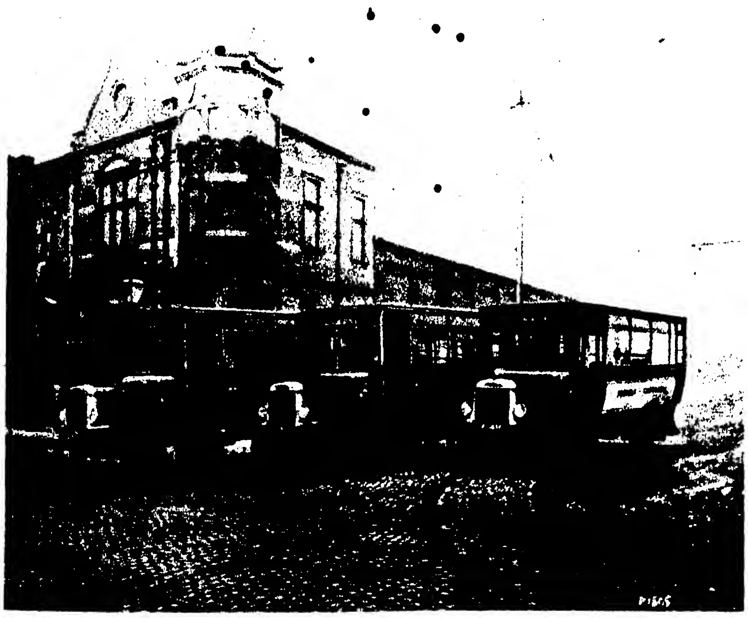
THE Corporation of Preston, Lancashire, having decided to run a transport service along the new Lytham Road route towards the sea-coast, considered the conflicting claims of tram and motor omnibus transport, and eventually decided upon the latter. In favour of the 'bus method was the fact that the laying of tramway tracks and the necessary equipment would have involved a heavy cost, and the inflexibility of a tramway service would have detrimentally affected the capacity of this busy thoroughfare.

For this particular service, therefore, the Corporation purchased three 32-seater Leyland single-decker omnibuses, and these are shown in the accompanying illustration. Two of the buses run a continuous service on week-days from 6.30 a.m., to 11.15 p.m., and it is stated that the engines do not stop running from the time of starting in the morning until the vehicles are garaged about 11.30 in the evening. They are certainly of a useful type, and one increasing in favour for many phases of passenger transport.



Royal Baggage Van, "Leyland" Type

Another Leyland production is the 3 ton baggage van, for H.M. The King, which we illustrate. This is a repeat order for Leyland's.



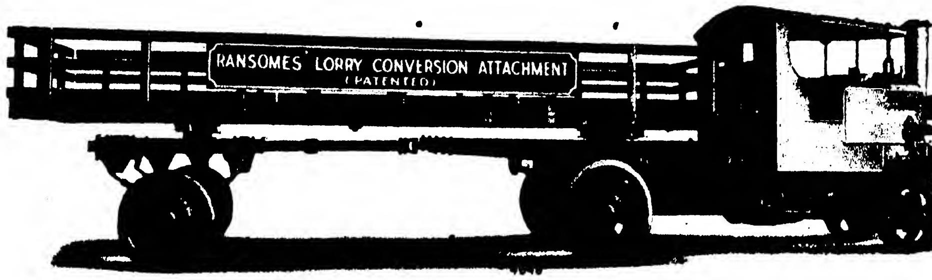
"Leyland", Single-deck Motor Omnibuses in regular Passenger Service

A New Lorry Attachment

WE have received from Messrs. Ransomes, Sims & Jefferies, Ltd., Orwell Works, Ipswich, some interesting particulars of their new Lorry Conversion Attachment, whereby the capacity of an ordinary lorry can be very considerably increased, and the general arrangement of this attachment will be clear from our illustration.

The employment of this Lorry Conversion Attachment in conjunction with any ordinary four-wheel steam or petrol lorry, converts the same into a mobile, flexible and efficient six-wheeler, increasing the body capacity of the vehicle approximately 100 per cent. and enabling up to double the normal paying load to be dealt with for a negligible increase in operating charges.

The Conversion Attachment is made in three sizes, viz: 1½/2, 3/4 and 5/6 tons capacity, and can be supplied for use with any standard type of steam or petrol lorry. It is particularly suitable for use when bulky



Lorry Conversion Attachment

Ransomes, Sims & Jefferies Ltd.

loads have to be transported, and an adequate brake is provided.

The Attachment is flexibly fitted to the rear end of the motor vehicle by means of a universal joint. A coupling pole of ample dimensions is provided. This coupling pole passes through the frame of the attachment and is located by two channels. It turns in these channels in order to compensate for the varying positions of the attachment on uneven ground. A bolster is fitted to the frame of the attachment. This bolster, to which the rear portion of the body is attached, is provided with a small turntable enabling it to swivel and tilt, so that neither the body nor load is distorted by the turning of the attachment. When a load is mounted on the combination body the Conversion Attachment will follow in the track of the prime mover without disturbing the load, since any relative movement of the forward bolster and motor vehicle will be compensated by the bolster on the sliding saddle, which is both pivoted and tilted.

An all important feature is that the wheels of the attachment absolutely track the driving wheels of the motor vehicle. The contrivance can thus easily negotiate all sharp turns. The six-wheeler resulting from the combination is quite simple to control, and can be turned in very confined areas, reversed, and manœuvred in a similar manner to any ordinary four-wheeler.

In addition, this Conversion Attachment, by virtue of its extreme flexibility, may be employed for use over the most difficult roads with every confidence, whilst the larger bearing surface and better distribution of the load, consequent upon the adoption of a six-wheeler, diminishes the wear on the road.

In conclusion, it is claimed by the makers that the six-wheeler in fuel consumption and carrying capacity, is the ideal heavy road transport unit at the present time, and by its use a saving of as much as 75 per cent. can be effected.

Reviews (*Continued from page* 172)

steam nozzles, feed pumps, economiser engines, mechanical draught, etc., etc. This figure in itself shows the great importance on this particular point.

Another important point on which the average purchaser of power plant is generally hopelessly ignorant, is the fact that boiler capacities are based on the amount of water evaporated per pound of coal. Standard practice is to take the number of pounds of water evaporated from and at 212 deg. F, but makers of boilers naturally give such figures when using a good quality of coal, and as Mr. Brownlie points out in his book the heating value of one pound of coal may be anything from 7,000 B.Th.U., to 14,500 B.Th.U., these figures meaning, of course, that the coal consumption is approximately 100 per cent. greater when coal of the lower value is used. Mr. Brownlie's very practical suggestion on this point is that the code should read lbs. of water evaporated from, and at 200 deg. F., per 1,000,000 B.Th.U., and we see no reason why manufacturers of steam plant could not adopt this sensible suggestion as standard practice immediately, without waiting for any conference on the subject.

Mr. Brownlie has designed an entirely new Code, which he describes at great length, and which he suggests should form the basis for a new international Code to be agreed upon by American, French and British engineers. He also gives many new ideas in addition to the Code which he has drawn up, and one of the most interesting of these is a new curve which he suggests as a correction factor in calculating the efficiency according to the heating value of the coal. His point is that it is ridiculous to work out the efficiency of a boiler plant merely from the heating value of the coal, that is to say, a very high-class coal could give say 80 per cent. under the best conditions, whereas cheap and inferior coal could only give 65 per cent. and there is little sense in comparing the working of these plants based merely on the heating value of the coal.

The book is full of stimulating and original ideas of this kind, and really the whole question of boiler plant testing is undoubtedly complicated to a degree which is quite unrealised by most engineers. The main point is that efficient steam generation has got to be regarded from a purely business point of view, and as Mr. Brownlie expresses it, boiler plant testing is necessary for the utilitarian purpose of saving money. Mr. Brownlie finally waxes very sarcastic on various other points in the Civils' Code, and certainly the methods they suggest for the carrying out of a boiler trial do seem to be extraordinary, including the pulling down of the whole of the main steam pipes to put up steam driers, and making-up pieces, the complete alteration of the feed pipe circuits, the determining by hand measurement of the exact size of the steam nozzles, even if there are several hundred of these, to lead up to the official test, which may be only three hours. All this, of course, has its humourous side, and we must confess we never expected to find material bidding character as boilers and boiler plant testing.

The Colloidal State

The Colloidal state of substances is one which is frequently met with in present day writings, and as it is not by any means generally understood, we propose to give a very clear description which is taken from a fascinating book entitled, "Chemistry in the Service of Man," by Alexander Findlay, M.A., D.Sc., F.I.C.

WHEN one brings sugar, salt, washing-soda, and many other common and familiar substances into contact with water, the solid substance, if present in not too large amount, disappears; it dissolves, and a clear liquid is obtained which we call a solution. For long, chemists and physicists have puzzled over this process, and they puzzle even yet: for while some consider the production of a solution to be due to the chemical combination of the dissolved substance, or solute, with the solvent, others see in the process nothing more than the mechanical intermingling of the molecules of the constituents of the solution. Doubtless there is truth in both these views, but even if combination does take place we must not regard the solution as a whole as being a compound of water with the sugar, salt, or whichever other substance is taken. A compound is characterised, by the fact that its composition is perfectly definite and constant, and cannot be altered by adding more or less of one of the constituents. The composition of a solution, however can be altered as we please; the proportions in which the solid and the liquid are present in the solution may be varied, in some cases varied very greatly, so that we obtain solutions of different strength or concentration. Even if chemical combination does take place it appears to do so only to a limited extent and is accompanied by a mechanical intermingling of the molecules. We may, therefore, regard a solution as being merely a homogeneous mixture in which the molecules of the dissolved substance or solute, combined it may be, with a limited number of solvent molecules, are uniformly disturbed throughout and among the molecules of the water, or other liquid which acts as the solvent. It is a homogeneous mixture of variable composition.

If, however, we leave on one side the question of the nature of the solution process, and consider merely the properties of the solution produced, one of the most remarkable facts established by the modern investigation of solutions is the very close analogy which exists between a substance in solution and a gas. For our present purpose it is sufficient to refer to only one feature of the analogy, the property of diffusion.

Kinetic Theory of Gases

To account for the properties of gases there was developed, about the middle of last century, a theory known as the kinetic theory of gases, which was based on the hypothesis that the molecules of a gas are in perpetual and rapid motion, darting about in straight lines with the speed of something like a mile a second, colliding ever and anon, some eighteen thousand million times a second, with other molecules, and pursuing, therefore, as the result of these collisions, a very zigzag course. It is by virtue of this motion inherent in the molecules that a gas can distribute itself or diffuse rapidly throughout a room, or can fill completely the space, however large that space may be, which is offered to it. In the case of liquids the same inherent motion of the molecules and therefore the same power of diffusion exists; but the process now takes place more slowly, for the molecules of the liquid are packed more closely together, and the mutal collisions are therefore more frequent. The forward progress of a molecule is therefore very slow, like that of a man who might try to pass through a dense and jostling crowd. But still diffusion does take place, as we can easily satisfy ourselves by gently pouring a layer of pure water on to a solution of some strongly coloured substance, such as bluestone (copper sulphate), or bichromate of potash. After some time we shall find that the coloured substance has diffused upwards some distance into the water. The experiment may be made more easily by dissolving in the water sufficient gelatin to make a firm jelly, and then placing a piece of this jelly in the coloured solution. After a few hours it will be found that the coloured substance has penetrated some distance into the jelly.

Even when the solution is separated from the pure water by a membrane of parchment paper, or by an animal membrane (*e.g.*, pig's bladder), diffusion takes place just the same, as we can show by enclosing the solution of copper sulphate in a tube of parchment paper which we then immerse in water. Very soon we shall be able to detect the presence of the copper sulphate in the water outside the membrane.

During the sixties of last century this diffusion of dissolved substances through a parchment or animal membrane was studied more fully by Thomas Graham, a native of Glasgow, who later became a Professor of Chemistry in London, and Master of the Mint. As a result of his investigation, Graham found that although

certain substances pass through a membrane of parchment paper other substances do not do so. Since the substances, *e.g.*, sugar or salt, which could pass through this membrane, were such as generally crystallise well, whereas those which would not pass through, *e.g.* starch, gelatin, glue, were amorphous and non-crystallisable, Graham divided substances into the two classes, crystalloids and colloids (from the Greek meaning glue), and this distinction was one which was long maintained. From a practical point of view, in any case, this distinction was of importance, for as Graham showed, if a mixture of crystalloids and colloids is placed in a parchment cell and immersed in water, the crystalloids, but not the colloids, diffuse out into the water. In this way a separation of crystalloid from colloid can be effected by a process to which Graham gave the name of dialysis, a process used universally at the present day for the preparation of colloids free from crystalloids.

Appropiate as Graham's classification of substances appeared at the time, recent investigation has shown that it cannot any longer be retained. The terms colloid and crystalloid can now no longer be employed to connote definite and different kinds of substances, but only different states of matter; for not only have substances such as albumin and gelatin, which Graham regarded as distinctively colloid, been obtained in the crystalline form, but even such definitely crystalloid substances as common salt have been obtained in the colloidal state. But language changes slowly, and although, through the advance of knowledge, a term may acquire a different signification, the term itself persists. And so one still speaks of colloidal substances, but means thereby substances in the colloidal state, which may be defined as a state in which one substance forms with another mixtures which, although they may appear homogeneous to the eye, even when aided by the microscope, are nevertheless heterogeneous, the diverse colloid particles having a magnitude greater than molecular. These apparently homogeneous, but in reality heterogeneous mixtures, are called colloidal solutions, or simply colloidal sols.

But it may be asked, how can we assert that these colloidal sols are heterogeneous mixtures, when we cannot detect any want of uniformity even with the aid of the microscope. The answer is, that even if we cannot see the particles themselves we can detect their presence, and the manner in which this can be done was shown long ago by Tyndall. Regard the air of a room bathed in a uniform light. Can you see any particles there? No. But darken the room and let a ray of sunlight pass through a hole or chink in the shutters, and what do you see? A diffused light the sunbeam made visible, in which the larger dust particles are seen to dance and swirl; the diffused light also being due to particles which are large enough to reflect and scatter the waves of light, although too small to be seen as separate individuals by the eye. So also, by means of this "Tyndall phenomenon," as it is called, the presence of particles in a colloidal sol can be detected. Pass a beam of light through pure water, or through a solution of salt, the path of the beam is invisible; the liquid is "optically empty." But pass the beam through a colloidal sol, and the path of the beam is traced by a diffused light, like the sunbeam in a darkened room.

Use of the Microscope

From this "Tyndall phenomenon," then, we learn that particles which may be too small to be seen in the ordinary way, may be detected if only the light reflected or dispersed by the particles, and not the direct rays from the source of light, are allowed to enter the eye. And it is clear that if, instead of the unaided eye, we employ a microscope to examine the scattered light, we shall still further extend our range of vision, and be able to detect, although not actually to see in their own shape and colour, particles which are much smaller than can be seen when the microscope is used in the ordinary way. Through the recognition of this principle there has been devised, in recent years, an arrangement known as the ultra-microscope, by means of which not only the heterogeneity can be detected, but also the number of particles in a given volume of the sol determined. A powerful beam of light instead of being directed into the microscope through the liquid to be examined, is sent horizontally into the liquid, at right angles to the line of vision through the microscope. If the liquid under examination is optically empty, the field of view in the microscope will appear quite dark; but if particles are present in the liquid, the light will be reflected and dispersed, and the minute points of light thus produced will stand out, against a dark background, in the field of view of the microscope.

And how large are those particles which are thus detected in the apparently homogeneous colloidal sols? With the aid of even the most powerful microscope, the smallest particle that can be seen by the ordinary method, must have a diameter of not less than about one sixty-thousandth part of an inch: but by means of the ultra-microscope, particles one-eightieth of this size, with a diameter of about one five-millionth of an inch, can be detected. This, however, is still about thirty times greater than the diameter of the hydrogen molecule.

From the investigations carried out by means of the ultra-microscope, it is found that colloidal sols may contain particles of very different size, even in the case of the same substance, and there is every reason to believe that there exist in some at least of the sols particles which are smaller than can be detected by the ultra-microscope, although they are of greater than molecular dimensions. In short, there appears to be no sharp division between colloidal sols and true solutions, and it is possible to pass gradually and without break from one to the other.

And now let us see what are the main properties of this colloidal state.

If we dissolve, say, two or three parts of gelatin in a hundred parts of water, we obtain a rather viscous liquid which, on being cooled down, "sets" to a firm jelly: and this jelly on being heated melts again to a viscous liquid. In this case, therefore, which is familiar to every one, a reversible change from the liquid or sol state to the state of a more or less rigid jelly known as a gel can be effected. If we add small quantities of salts to this gelatin sol there will be no apparent change, but it will be found that the temperature at which gelatin or the change from the liquid sol to the rigid gel takes place, is altered; it is raised or lowered according to the salt taken.

But a very different behaviour is found in the case, say, of the colloidal sol of sulphide of arsenic (arsenious sulphide), obtained by passing sulphuretted hydrogen into a solution of white arsenic (oxide of arsenic). This is a clear yellow coloured liquid which can be passed unchanged through filtering paper (a finely

porous, unglazed paper), it is as mobile as water itself, not viscous like the gelatin sol; and it does not set to a gel when cooled down. The water indeed, may be frozen to ice, but, on thawing the ice the sol of arsenic sulphide is obtained as before. The arsenic sulphide sol, also, differs very markedly from the gelatin sol in its behaviour towards salts. By the addition of even small amounts of different salts the sulphide of arsenic is caused to separate out as an insoluble yellow solid.

This marked difference in the behaviour of colloidal solutions of gelatin and of sulphide of arsenic, which may be taken as typical of two classes of colloids, is traceable to a distinct difference in the nature of the two sols. In the case of the gelatin sol we have a mixture of two liquids; it is comparable, therefore, with an emulsion say, of oil and water, and is, for that reason, called an emulsoid. When jelly formation takes place, a honeycomb structure is produced due to the separation of the sol into two parts. One part, forming the walls of the "honeycomb" consists chiefly of the colloid (gelatin), with a little water; the other part, filling the cells of the "honey-comb" consists chiefly of water with a little of the colloid. When such an emulsoid colloid is examined by means of the ultra-microscope, no definite particles are seen, but only a general diffused light.

In the case of the colloidal solution of sulphide of arsenic, however, we have a mixture, not of two liquids, but of a solid (arsenic sulphide), and a liquid (water); and examination with the ultra-microscope shows that the arsenic sulphide is present in the form of minute particles too small to be seen by the eye. Such a colloidal sol is therefore comparable with an ordinary suspension, such as muddy water, and is therefore called a suspensoid colloid.

One of the most marked characteristics of suspensoid colloids, and one which we have already seen demonstrated in the case of sulphide of arsenic, is found in the fact that addition of salts, or speaking generally, of electrolytes, brings about, with varying degrees of effectiveness, the separation or precipitation of the colloid in an insoluble form. A similar behaviour is found in the case of ordinary fine suspensions, *e.g.*, of clay in water, and this is sometimes of considerable geological or geographical importance. Thus, the sedimentation of finely divided, water-borne clay is markedly influenced by the purity of the water transporting it, taking place more radiply when salts are present than when they are absent. This, indeed, is one reason for the rapid deposition of river mud on mixing with sea-water, and for the consequent silting up of river mouths and the formation of deltas, such as has taken place at the mouth of the Nile.

But this precipitation of suspendsoid colloids and the sedimentation of fine suspensions by electrolytes, is counteracted more or less effectively by the presence of emulsoid colloids (*e.g.* gelatin or albumin) so that, in their presence, a much larger amount of electrolyte is necessary to produce precipitation or sedimentation. The emulsoid colloids exert a "protective" action, and the suspension or the suspendsoid colloid, is rendered much more stable. Indeed, so stable may the colloid become that the colloidal sol may even be evaporated to dryness without destroying the colloidal state; on treating the dried solid with water, it passes back again into the state of a colloidal sol. Such colloidal sols (*e.g.*, colloid silver or collargol), now find important uses in medical practice as powerful bactercides.

In the manufacture of photographic plates, prepared by coating plates with gelatin containing a fine suspension of silver bromide, we have an important industrial application of the protective action of emulsoid colloids. If a solution of potassium bromide is added to a solution of silver nitrate, silver bromide is formed and separates out as an insoluble curd, quite unsuitable, on account of its coarseness, for photographic purposes. But if gelatin is first dissolved in the solutions of potassium bromide and of silver nitrate, no curdy precipitate, but only a uniform colloidal suspension of very fine particles of silver bromide is obtained on mixing the solutions.

The protective action of emulsoid colloids and the precipitating action of salts, are excellently illustrated, also, on a large scale in nature. Some of the great rivers of the world, like the Mississippi, and the storied Nile, whose turbid waters have from time immemorial carried in their bosom the promise of bountiful harvests are always muddy, whereas other rivers which are even more swiftly flowing, like the Ohio, are, except in times of flood, perfectly clear. In the case of the first two rivers there is much colloidal organic matter washed into them by which the clay and soils are retained in a state of fine suspension; and it is only when the rivers reach the salt waters of the sea that the suspended matter is precipitated with the production of river bars and deltas. In the case of the River Ohio, however, the water remains clear, owing to the absence of colloidal organic matter and the presence of lime and other salts.

A New Slide Rule

We have received from J. Rieger, Professor of Reinforced Concrete Structures at the Polytechnic High School of Brno, Czechoslovakia, some particulars of a new slide rule which has been brought to perfection after some twelve years of labour, for the purpose of eliminating the somewhat tiresome and fatiguing process caused by the ordinary method of calculation, where it is not possible to arrive at the result by the first attempt.

The rule is applicable to the determination of tensile, compressive and shearing stresses in beams, direct compression in struts, pillars and columns; combined bending and direct stresses; and to arithmetical operations including multiplication, division, involution, and evolutions. An instruction book in either English, French, Czech completes the equipment. With this instrument engineers can readily prepare designs for every type of reinforced concrete structure and can check the accuracy of the designs submitted by firms in competition. Full particulars may be obtained of this Slide Rule on application to Mr. Rieger, at the above address.

Reviews

BOILER PLANT TESTING.—By David Brownlie, B.Sc. Hons. (Lond.), F.C.S., A. M. I. Min. E., Am. Soc. M.E., A.I.Mech.E.

Published by Messrs. Chapman & Hall, Ltd., 11 Henrietta Street, London, W.C.2. Price 10s. 6d. nett.

This new text book on steam boilers may be said to be unique. We do not remember ever having read a text book which carried so much criticism of existing methods as does this new publication of Mr. Brownlie's.

It is, however, by no means all criticism, and the first sentence in the introduction gives the key to the contents. This sentence reads as follows: "There is at present no practical and definite code in Great Britain, for boiler plant testing, and consequently such tests are largely carried out according to the fancy of the particular engineers engaged."

As is generally known, Mr. Brownlie has been responsible for carrying out a very large number of boiler tests throughout Great Britain, and during the process has collected a vast amount of data on the subject. His new book records the results of these tests, and at the same time forms the basis for a new standard code of boiler testing, and he proposes that such code should be compiled by the combined efforts of the leading institutions of Great Britain, America and France.

Regarding Mr. Brownlie's criticism it is mainly against the standard code adopted by the Institution of Civil Engineers, London, and we propose to refer to a number of these criticisms and in doing so we would remark that Mr. Brownlie's very severe attitude towards them would seem to show that this code is apparently in a very similar position to some of the old British laws, that is to say, that they have become fossilised with age, and that they should now be taken in hand in a systematic manner and brought up to date in every detail.

The early part of Mr. Brownlie's book gives a vast amount of detail relating to his tests, and briefly they show that the nett working efficiency of some 400 different boiler plants, having a total coal bill of 3,250,000 tons per annum, with 1,513 boilers in 49 different industries is only 58 per cent.

The author states that boiler plants are being worked in Great Britain at any figure from 32.5 to 82.2 per cent. efficiency. The nett result of 100 colliery boiler plants, with 570 boilers and a total coal bill of 1,250,000 tons per annum, is a nett working efficiency of 55.52 per cent., 60 boiler plants in the Chemical Industry, with 236 boilers, and a total coal bill of 620,000 tons per annum, give 57.9 per cent., whilst 65 boiler plants in the Dyeing, Bleaching, Calico-printing, Finishing and Allied industries, with 217 boilers, and an annual coal bill of 275,637 tons, showed a nett working efficiency of 61.41 per cent. Also, 40 paper-mill boiler plants, with 112 boilers and a total coal bill of 291,145 tons, gave an efficiency of 65.07 per cent. In general the author states, as a result of his extensive experiments, that of the 90,000,000 tons of coal per annum burnt in Great Britain for steam generation, no less than 20,000,000 tons are being thrown away through lack of modern scientific methods, that is to say, the adoption of such methods would reduce the annual coal consumption of steam boilers by 22 per cent. Mr. Brownlie gives this mass of information, based upon his own original work, merely as an argument that it is absolutely essential to test boilers regularly, and that it is necessary to have a proper Boiler Testing Code.

Mr. Brownlie deals in a very lucid manner with the particularly difficult question of the gross and nett heating value of the coal, and suggests that the determination of hydrogen should be abandoned altogether, taking the gross heating value of the coal based on its analysis in a bomb calorimeter.

The analysis of the flue gas is dealt with at great length, and Mr. Brownlie has some very pungent remarks to make regarding the Institution of Civil Engineers' Code in this respect. Mr. Brownlie states that this Code regards all instruments of precision, such as water meters, steam meters, combustion recorders, pyrometers, etc., with contempt. The code, Mr. Brownlie states, condemns all CO_2 recorders as being inaccurate, although he says there are 15 or 20 different makes on the market, most of which dave been tested by the National Physical Laboratory. The Civils' code, however, goes on to say that if CO_2 recorders must be used, the best machine is the "Ados," and Mr. Brownlie very unkindly points out that this is an entirely obsolete German machine, the last of which was sold in this country in 1907. This particular instance probably puts Mr. Brownlie's case in a nutshell as regards out-of-dateness of the present Civils' Code.

Another rather extraordinary example given by Mr. Brownlie, is with reference to gas sampling apparatus, when he states that the Civils' Code recommend some method published many years ago by Professor Breckenridge of America, and that Mr. Brownlie has written out to America to try and get hold of this, and that he has not been successful, but he learns from the United States Geological Survey, that it is obsolete and has been out of print for some years.

Still another point is the question of measuring feed-water. Mr. Brownlie states, that there are about 20 water meters on the market, but in spite of this fact the Civils' Code refuses absolutely to have anything to do with water meters, and insists on the tank method even for testing at sea.

Considerable attention is given in the book to the intricate question of the amount of moisture in steam, and also to the question of the specific heat of steam. Here again the Civils' Code seems to take up a hopelessly out-of-date attitude, insisting, for example, upon the standard figure of 0.48 per cent. for the specific heat of steam. As Mr. Brownlie points out, Knoblauch and Jakob's famous work upon the superheat of steam can be purchased in the form of curves for a few pence, and shows that this figure varies from 0.45 to 0.685.

A further important point which Mr. Brownlie emphasises is the steam used as auxiliary power in the boiler house; this is a point which is frequently ignored by power plant manufacturers when in competition in selling their plant, and the innocent purchaser is not likely to be able to make comparisons on this particular factor, unless he happens to have the services of the competent consulting engineer. Mr. Brownlie states that in the average boiler house, the auxiliary apparatus is taking anything from 3-12 per cent. of the steam generated for the use in

(*Continued on Page* 168.)

HOW & WHY THINGS WORK

Conducted by J. HAGGIE-PATTERSON, Assoc. M.I.C.E.

THIS SECTION IS PRIMARILY INTENDED FOR ENGINEERING STUDENTS AND DEALS IN SIMPLE LANGUAGE WITH THE CONSTRUCTION AND WORKING OF VARIOUS TYPES OF PRIME MOVERS AND INDUSTRIAL MACHINES AND DEVICES

Small Talk on Railways (v)

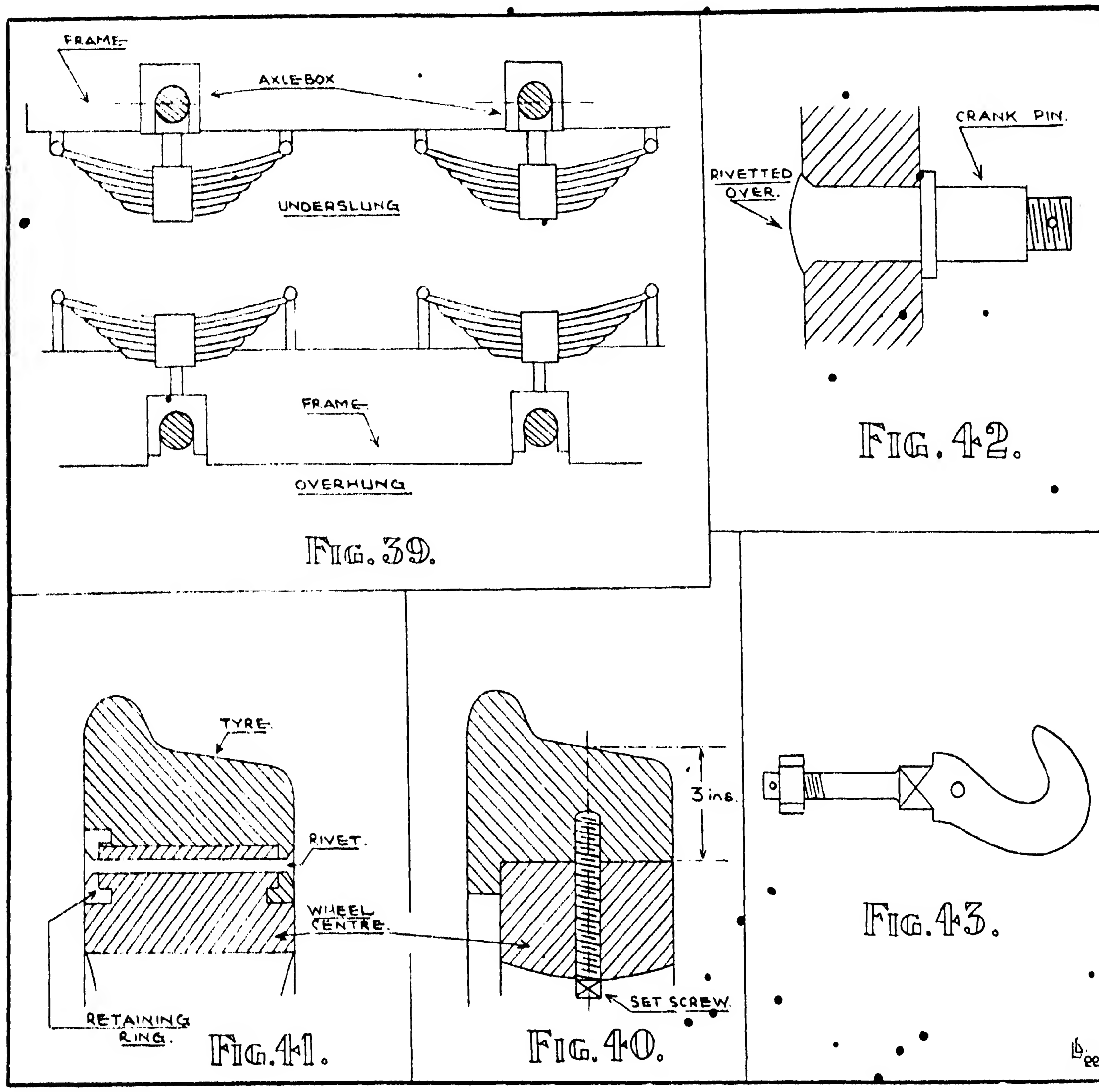
CONSIDERING now the springing of the Locomotive: the general practice is to use lamenated steel springs, and there are two systems of arranging these, namely, the underslung and the overhung methods. (See sketch No. 39). Of course, with the overhung system, there is no doubt that the springs are well up, and therefore, are not apt to foul, and are generally easier to get at. In both types of springing the forces which act on the spring are identical. Regarding the wheels, these are built up generally with Cast Steel Centres, which are bored to receive the axle, and turned on the outside to receive the tyre. The tyres are made of a very hard steel, and the diameter to which they are bored is fixed, so that to get the tyre on to a wheel centre, it has to be heated, to a temperature of about 250 degrees. When the axle has been pressed home, the tyres are then placed on the wheel centre, which it naturally grips, due to the contraction upon coming back to normal temperature.

A second check, to stop the tyre from coming off, can be carried out in one or two ways. One way which is generally adopted by the Indian Railways, is to place a set screw nearly midway between each spoke, which is screwed through the rim of the wheel centre and into the tyre, generally to a depth of about 1½ in. (See sketch No. 40). In England most of the tyres are fastened on by the use of a retaining ring and rivets, the latter go through this retaining ring, the rim of the centre, and then through the flange on the tyre. (See sketch No. 41). Tyres when first put on to the centres are generally about 3 in. thick on the tread, and are scrapped when they wear down to about half this thickness. Referring to the amount of contraction which is allowed on a tyre, this is about 1,000th part of its diameter, being found to be all that is necessary. Crank pins where they enter the wheel centre are sometimes parallel, and sometimes slightly tapered, and are pushed in under hyrdaulic pressure, and finally riveted on the other side. (See sketch No. 42).

When one reads of, say, a 5 ft. 6 in. gauge Locomotive, this means the distance between the rail centres; there are numerous gauges all over the world, such as 4 ft. 8½ in., metre gauge, or 3.28 ft., 3 ft. 6 in., 60 cm., or 2 ft.

Now that the main points on a Locomotive Engine have been explained, the next thing to consider, is how the forward motion is transmitted to the train which it draws behind it, and this is done by the use of a draw bar. (See sketch No. 43). The section of a draw bar is generally about five square inches, and made of best Yorkshire Iron, so that the hook will generally bend before it breaks, the load that this would bear before if finally broke would be, roughly speaking, about 110 tons, and when one comes to think that the pull required to start a pretty heavy train from rest is about 9 tons, this gradually dying away to 3 tons, when the train is moving at a speed of about 50 miles per hour the safety factor of these draw bars is quite high, being about 11 to 1. The forward motion of the Locomotive is caused through the adhesion between the wheels and the rail. When the wheels are made to revolve, due to the entrance of steam into the cylinders, this force causes a turning movement on the wheel, through the connecting rod and crank pin, this motion is called tractive force, and therefore varies in power, according to amount of adhesion and the number of wheels which utilize adhesion. To apply the principle of work to "Tractive Force," means "The work done by the steam on the piston, is equal to the work done on the rail by the tyres due to friction."

From this the reader will now see that the more coupled wheels one has on a Locomotive, the greater the tractive force, the other wheels are merely for running purposes. Take an engine with a gauge of 5 ft. 6 in., when the weight per axle will run about 13.5 tons, therefore the number of coupled wheels, bearing this weight, will require to be multiplied by this weight, to arrive at the total tonnage available for adhesion. In very dry weather each of these tons represent 600 lbs. of adhesion, in very wet weather 550 lbs., misty weather or greasy rails 300 lbs., frost or snow, about 200 lbs. so that supposing the Locomotive was an eight wheeled coupled (*i.e.*, four axles coupled together), then the tonnage suitable for adhesion would be 54 tons, and the total pulling power of the engine, in dry weather, would be 600 by 54=32,400 lbs., which equals 14½ tons. In misty or foggy weather, this would mean about 7.25 tons, and is called the "Draw Bar Pull," which is the technical way of expressing the value of Locomotive power. In the case of a metre gauge engine six wheeled coupled, the load per axle is roughly 8 tons, and therefore, in dry weather the draw bar pull would equal to 6.25 tons. From the above, the reader will see that adhesion, limits the size of cylinders on a Locomotive, and thus finally, the weight on the axles, which is governed by the strength of permanent way materials.



Locomotive Details

THE CHANNEL TUNNEL

One of the most important transportation links in the world has yet to be forged, and once this has been done there can be little doubt that there will be a tremendous development in both passenger and freight traffic, between the British Isles and the Continent of Europe. This tunnel under the English Channel, which has been the dream of many transportation enthusiasts for years, has been long delayed, and despite very strong support for it both in England and France, there still appears to be some grave reason to urge the responsible authorities to look askance at the proposal. It cannot well be a military reason, because the improvement in aerial transport has made England no longer an island, but that there is some strong objection to the construction of the tunnel was indicated the other day in answer to a question raised in the House of Commons. From the public point of view, it is indisputable that the great mass of opinion is directly in favour of the construction of this important link, and as *The Times* well said recently it surely is not beyond the wit of man to devise safeguards which would satisfy any nervousness that may exist on military grounds. It has been suggested that the work might be executed by German labour in part discharge of their reparation liabilities, but this is a method which may be regarded from more than one point of view, and is not generally favoured.

INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

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BETWEEN OURSELVES

The Production of Iron and Steel direct from the Ore

THE idea of obtaining iron and steel direct from the iron ore is again attracting much attention. It has, of course, been realised for a long time that, from a theoretical and scientific point of view, the blast furnace process has a number of objections. In the first place the reduction of iron oxides (iron ore) to metallic iron by this method results in a very impure product, because numerous other substances are reduced at the same time and become mixed with the iron. Consequently an expensive secondary treatment for purification by means of the converter or open hearth furnace is necessary. Also, the reduction of iron oxide to metallic iron can be carried out at 1830 deg.F. (1000 deg.C.), whereas in the blast furnace the actual temperature obtained is about 3000 deg.F. (1650 deg.C.), resulting in a great waste of heat and the lowering of the efficiency of the process. Many attempts have been made to regulate the reduction of the iron ore, so that malleable iron or steel can be obtained direct without the necessity of expensive secondary treatments, and the two chief direct processes now coming to the front are the " Basset " and the " Bourcoud," both of French origin.

In the " Basset " process the iron oxide is mixed with powdered coal and heated in a rotary kiln at 1,830 deg.F. (1,000 deg.C.), by means of a powdered coal flame, the lower end of the kiln receiving the molten iron and slag. It is not very clear as yet what are the practical results of this process, whether some of the iron will not be lost by re-oxidation, and whether ordinary iron ore will in this way yield a pig iron much purer than the ordinary blast furnace product, and particularly also what will be the coal consumption of the process.

The " Bourcoud " process consists essentially first in the separate manufacture of a strongly reducing gas at high temperatures, and then the separate reduction of the iron ore by this gas in a revolving furnace. As the reducing temperature is never sufficiently high to fuse the iron produced, there is installed as an auxiliary for the purpose an electric smelting device. A special producer plant is used for the gas production, in which pulverised fuel is injected with heated air, and the time element necessary for the maximum production of CO (carbon monoxide), is given by causing the products of combustion to travel through long flues. Almost any fuel can be used in this producer, coal, oil, lignite, etc. The reducing gas is then led into the rotary furnace containing the iron ore, which has a special lining, so that the gases are compelled to follow a long spiral path and come into comparatively prolonged contact with the ore, whilst travelling also in the reverse direction. The temperature of the reduction of the iron oxides to iron is so low that the impurities in the ore, especially sulphur and phosphorus compounds, are not reduced at all and pass direct into the slag, along with the silica and manganese compounds. The mass left in the furnace, chiefly pure reduced iron, is then taken out of the furnace, compressed, and melted in an electric furnace without any air being present. The enormous possibilities presented by this process are obvious, and further information will be awaited with great interest.

* * *

The Liquefaction of Coal

The development of the low temperature carbonisation of coal has forced us to realise that the burning of raw coal, and the consumption as mere fuel of all the valuable volatile matter, constituting in averages 25-30 per cent. of the weight of the coal, is a thoroughly uneconomical and unscientific proceeding. Thus, by low temperature carbonisation, 1 ton of coal is first made to yield 3-4 gallons motor spirit, 18-20 gallons oil, and 15 lbs. sulphate of ammonia, before being used as fuel in the shape of low temperature coke. A vast amount of research work is, however, being carried out with the object of still further increasing the yield of liquid products from coal, and in this connection the publications of the Coal Research Institute at Mulheim (Westphalia), are of great interest. One of the general lines of research investigated, which is also attracting much attention in Great Britain, is the treatment of the pulverised coal with hydrogen, which reacts with a considerable portion of the complicated organic compounds constituting coal, so as to increase the yield of hydrocarbons. Thus at high pressures, about 1500 lbs. per square inch, and at a temperature of say 572/662 deg.F. (300-350 deg.C.), a large amount of hydrogen is absorbed, and the greater portion of the coal substance is converted into liquid, and low melting point solids, chiefly hydrocarbons, without any gas, whilst almost the whole of the nitrogen is converted into sulphate of ammonia. The German investigator Bergius is stated to have converted no less than 80 per cent. of coal into hydrocarbons, and substances allied to the phenols, by treatment with hydrogen at still higher temperatures and pressures. It is well realised that coal is very susceptible to oxidation, as we know from coal storage troubles, and Fischer and Niggermann have shown, as a result of a long series of researches, that ozone has a remarkable action on

coal, and that many qualities of coal can in this way be completely liquefied and converted into complex acid organic compounds containing oxygen, and soluble in alcohol or water. By this method it is stated that even an anthracite coal, containing only about 3-4 per cent. volatile matter, can be converted into 48 per cent. of liquid products. The method, however, is too costly for practical application, and experiments are now being carried out with compressed air. The coal is finely ground and mixed with a solution of sodium carbonate, and then treated with compressed air in steel containers at 338/392 deg.F. (170/200 deg.C.) Oxidising methods of this description yield about 40 per cent. of the weight of the coal in the form of soluble organic compounds. There is every prospect, therefore, in the near future of actually liquefying many varieties of coal and lignite, and obtaining an enormous yield of motor spirit and "Diesel" oil.

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London to Bombay Air Service

The Shell Company, in conjunction with Commander Burney and Messrs. Vickers, have put before the Home Government a proposal to run a mail and passenger service by Airship to India. The Airships will be five million cubic foot capacity, capable of flying at 80 m.p.h., and carrying 200 passengers. The probable fares, London to Bombay, will be £70 first, and £45 second class. Monthly return tickets £90 first and £60 second class. The proposal was put forward in order to develop Empire communications in speed and cheapness, as owing to the economic chaos in Europe resulting from the War the commercial community are turning to the Empire as their field for development. No promotion profits are being taken by any party, and all that the promoters require is a subsidy sufficient to pay the public investor a small but certain dividend of 4½ per cent. tax free on debentures, and 6 per cent. tax free on ordinary shares. It is suggested that India should contribute £40,000 a year until the Company is making profits, but limited to ten years. Admiralty and Air Board consider the scheme feasible, but the Cabinet doubt India assisting Home Government with contingent guarantee, and appear unwilling to bear the whole liability *themselves. If India wants* a service from London to Bombay in three and a half days it is urgent that Home Government should be informed that subject to ratification by Parliament and approval of Home Government that India will contribute £40,000 a year."

New Apparatus Determining the Efficiency of Boiler and Pipe Coverings

Mr. C. Jakeman of the National Physical Laboratory, has devised an improved electrical apparatus for testing the efficiency of boiler and pipe coverings at the high temperatures now being adopted in super-station work. The new apparatus, which is an improvement on a previous one, which however, only had a range up to 450 deg.F., consists of two lengths of 4 in. mild steel pipe, the ends being closed by blind flanges. In order to eliminate radiation errors from these flanges, one pipe is much shorter than the other, 13¾ feet, as against two feet, and the apparatus is so arranged that the errors are eliminated by difference and the actual length of pipe tested free from these errors is the difference in the length, that is 11¾ feet. The pipes are heated inside, by means of six concentric circles of wire through which an electric current is passed, so arranged that, irrespective of the number of sections of wire that are in operation, the heating is always uniform. If all six sections are in operation the current required is about 20 K.W., and the temperature of the surface of the bare pipe is about 1,000 deg.F. In calibrating the apparatus and maintaining the pipe continually at any required temperature, two methods are used, first a platinum wire placed just inside the pipe walls to act as a resistance thermometer in the usual way, and secondly a number of thermo-electric couples soldered into tiny holes drilled in the wall of the pipe.

The tests are carried out by determining first the amount of electrical energy required to maintain a standard temperature in the bare pipe for a number of hours, and then carrying out the same observations with the pipes covered and maintained at an equal temperature, subtracting the figures for the short pipe from that of the long pipe in order to get the nett figures for the true test length. In this way any quality of boiler and pipe covering can be tested for efficiency under varying conditions of pipe temperature and thickness of covering. A good class covering such as 85 per cent. Magnesia, Slag Wool, and Asbestos-Diatomite mixtures, will give 92-95 per cent. efficiency, and it can only be emphasised that it is the poorest possible policy to buy cheap and inferior coverings anything from 70-80 per cent. efficiency.

Railway Supplies for India

In answer to a recent question in the House of Commons, Lord Peel, Secretary for India, issued a written statement giving particulars of orders for locomotives, rolling stock and railway material for India, which had been placed in Great Britain, Germany, Belgium and America, since the Indian Government entered on its new railway programme. The statement indicated that the orders placed since March 1st, 1922, by the High Commissioner for India, in respect of State railways included £19,000 for locomotives and parts, and £1,700 for general stores (a total of £20,700 from America and £18,200 for locomotives from Sweden. Great Britain had received orders for £355,500, representing £84,000 for locomotives, £147,000 rolling stock, £9,200 for permanent way materials and £115,300 in respect of general stores. Germany had received orders for £15,100, mainly for rolling stock, and Belgium orders for £4,100 for rolling stock and permanent way materials. These figures relate solely to the State railways, but similar figures are being obtained as to the orders placed on behalf of the company-worked railways, and as they are of especial interest just now, the figures will be given in these columns as soon as they are available.

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On page 83 of our September issue we omitted to insert below the section of the Impulse type steam turbine that it was by The British Thomson-Houston Co., Ltd.

INDUSTRIES

Conducted by FRANK DAWSON.

THIS SECTION DEALS WITH THE GREAT BASIC INDUSTRIES OF INDIA. IN THE PRESENT ISSUE WE DEAL PARTICULARLY WITH IRRIGATION

Irrigation Enterprise in India

*The following extracts are taken from the remaining portion of Mr. F. W. Woods paper, read before the Royal Society of Arts (Indian Section). This paper deals with the subject in a most complete manner, but we are only able to give here some of Mr. Woods reasons for condemning the Sukkur Barrage scheme, and to refer to his alternative proposal.**

The Sukkur Barrage Irrigation Project (1920)

THE contemplation of these excellent results has encouraged the engineers and revenue officials of Bombay and Sind to put up a project, known as the Sukkur Barrage Irrigation Project (1920), which, according to its promoters, will easily put all other projects, present or past, whether in or out of India, in the shade, by comparison with its figures of cost, and the vastnesss of its scope.

My attention was drawn to this project, which has received the approval (subject to compliance with certain financial precautions) of the Secretary of State for India, by perusal of a report of a lecture delivered on the subject a year ago in London, by Dr. Summers, C.I.E., the well-known expert irrigation engineer of Sind. So that when I was honoured recently by an invitation to discourse before this distinguished Society on the subject of "Irrigation Enterprise in India," I felt that I could not serve the Indian public and the Government of India better than by offering my opinions on this important project for what they may be worth.

Physical Conditions of the Indus Riverain

The River Indus, from the point where it enters the Province of Sind 80 miles upstream of the rocky gorge at Sukkur, down to its mouths at the sea-coast, about 400 miles downstream of Sukkur, lies along a ridge, alluvially formed by its own deposits of sediment, at an appreciable elevation (about 20 feet) above well-defined valleys, known as the East and West Nara, respectively, which lie, one on either side of it, at distances varying from 5 to 50 miles. These Nara valleys represent what may have at some period in the past been the bed of the river; and it is quite on the cards that the river may at some future period abandon its present elevated ridge and breach its way into one or other of the lower lying valleys. A brief reflection suffices to show that it is comparatively easy to irrigate from the river, in its high-water season, the greater part of the ridge of fertile soil that has been alluvially formed by the deposits of silt from its own floods in the past. And we find, as a matter of fact, that such irrigation has been practised in the past, from time immemorial, by the primitive devices of the local population; long before the British occupation of the country introduced some more scientific methods into their design, construction and control. The gross area of land thus commanded by existing irrigation canals in Sind amounts to nearly 18,000,000 acres; of which it is reckoned that nearly 11 million acres represent culturable soil.

The area irrigated annually by the existing inundation canals of Sind amounts to about 3 million acres, or about 27 per cent. of the estimated culturable area of the Province, and it is natural and intelligible that the Bombay Officials should wish to double or treble, if possible, the area irrigated annually. But it is equally intelligible that their lack of experience of perennial canal irrigation may hide from their minds the natural limitations to any very great increase of intensity of perennial irrigation, in the peculiar alluvial formation to which I have drawn attention.

Outlines of the Sukkur Project (1920)

The Sukkur Barrage Irrigation Project provides for the construction of a Barrage, or bridge-way fitted with sluice gates, across the River Indus at Sukkur, capable of holding up the water of the river to a level of 194.5 feet above the mean sea level at Karachi, for the purpose of irrigating the whole of the land on either side of the river, from Sukkur down to the town of Hyderabad. The gross area of land thus commanded by flow is estimated to amount to about 7½ million acres, or 50 per cent. greater than the entire area commanded by the irrigation canals of the Nile, in Upper Egypt combined. It is also more than double the gross area commanded by the Lower Chenab Canal, and just double that of the Triple Canal Project of the Punjab.

The Sukkur Barrage Project aims at irrigating annually an area of 5,300,000 acres; rather more than the total culturable area of Upper and Lower Egypt combined; more than double the area irrigated annually by the Lower Chenab Canal, and nearly treble that of the Triple Canal Project. The cost of the estimated Sukkur Barrage Project is 1,842 lakhs of rupees (about £12,300,000), which is nearly seven times the actual cost of the Lower Chenab Canal, and nearly double the actual cost of the Great Triple Canal Project of the Punjab.

These data will suffice to give a fair idea of the magnitude of the Sukkur Barrage Irrigation Project.

**Note—All blocks used in this article are loaned by courtesy of the Royal Society of Arts*

The Report impresses me as being the work of an engineer of more than average industry, zeal, and ability. But no amount of natural ability on the part of an engineer can make up for a lack of practical experience of perennial canal irrigation, in the preparation of the designs, estimates, and financial forecasts, of by far the greatest scheme of perennial canal irrigation that has hitherto been seriously put up for approval.

Comparison between Upper Sind and Middle Egypt

The River Indus and the Province of Sind have many points of resemblance, in physical characteristics, meteorology, etc., with the River Nile and Egypt.

Sind, like Egypt, is remarkable for the scantiness of its rainfall. The climate of Sind is much hotter than that of Egypt, but the rainfall of the latter country is even scantier than that of the former.

The Indus, from Sukkur to Hyderabad, a distance of 240 miles, resembles the Nile in Middle Egypt from Assiut to, say, Cairo (235 miles), in that it flows on an elevated ridge formed of its own alluvial deposits by spill; and in that it is flanked by lateral valleys at a lower level than its own marginal land.

And downstream of Hyderabad, down to the sea coast, the Indus has the physical characteristics of the Nile in Lower Egypt.

There is in Middle Egypt an ancient channel, the Bahr Yusuf, which probably represents a former channel of the Nile, long since abandoned. The Bahr Yusuf runs roughly parallel to the Nile, at a distance of about five miles, but at a level which enables it to act as a drain, and it has a separate outfall at a low level, into the depression known as El Fayum. Similarly, in Sind there is an ancient natural channel, the Narra (or East Nara), roughly parallel to the Indus, at a distance of about 50 miles from it, but at a level roughly 20 feet lower.

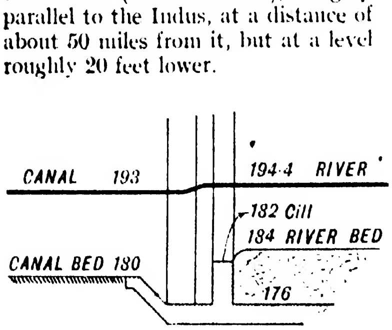
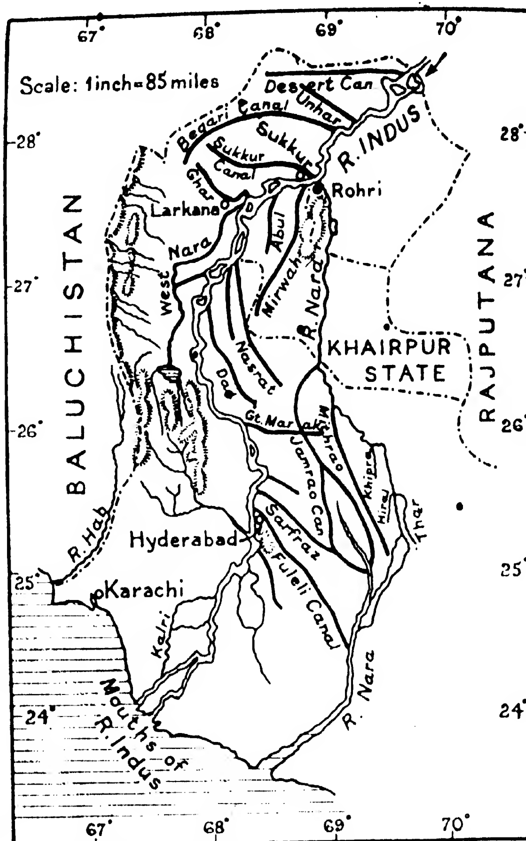


Fig. (6) Section through Canal-Head on line of flow (1920 Project)

The Narra River

The Narra may represent a former channel of the River Indus; or it may even represent the long-lost *sixth* river of what is *now* known as the Punjab (Five Waters), but which might formerly have been called the "Chhe-n-ab" (Six Waters). The five existing rivers of the Punjab, viz., the Jehlam, the Chenab (Chhenab?), the Ravi, the Bias, and the Sutlej, are known, in the reach below their final confluence, where they are united in a single stream, as the *Punjnad* (Five Streams)—a word synonymous with *Punjab*. The perished River Narra (Nurra, or Nara), is known also in Sind as *Hukkra*, a name which is also applied in the Punjab to the "lost" river, which can be traced upstream through the deserts of Bahawalpur and Bikanir, to Hissar and the Naf-dak; where it may be identified with the Ghuggur, Chitang, and Saraswati, flowing from the direction of Thanesur the sacred shrine of Kurukshetra, second only in sanctity to Hardwar, on the Ganges. It is conceivable, even, that the River Jumna flowed, at some remote period in the past, into the Indian Ocean, *via* the alignment indicated by the existing Saraswati Hukka or Narra, Channels, thus forming the *sixth* river of the Chhenab (now Punjab), before it, as the result of some extraordinary natural avulsion, turned away to the left and joined the Ganges to flow into the Bay of Bengal.

However this may be, the position of the Narra channel, relatively to that of the Indus, corresponds to that of the Bahr Yusuf relatively to that of the Nile in Upper Egypt. With this noticeable difference, however, that the practice, continued for centuries past, of "basin" irrigation in the Nile Valley, has had the effect of silting up the valley between the Nile and the Bahr Yusuf; whereas no such action has occurred between the Indus and the Narra.



The River Indus and existing Canals of the Province of Sind

Comparison of the Indus with the Nile

The *average monthly* discharge of the Nile at Assiut ranges from a minimum of 21,000 cusecs in May up to a maximum of 325,000 cusecs in September; whilst the average yearly discharge is 107,000 cusecs.

The *average monthly* discharge of the Indus at Sukkur ranges from a minimum of about 20,000 cusecs in January-February, up to a maximum of 460,000 cusecs in August; whilst the average yearly discharge is 107,000 cusecs—the same as that of the Nile.

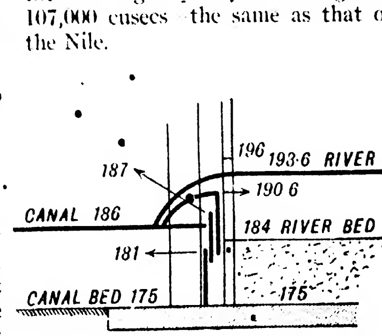


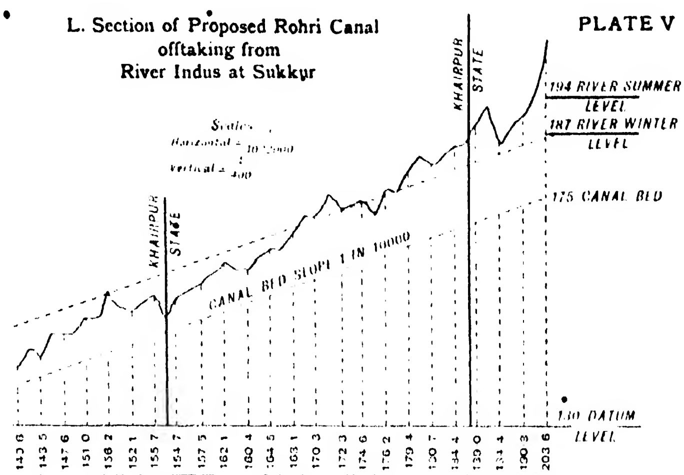
Fig. (6) Section through Canal Head on line of flow (Woods' Design)

These figures indicate that the flood season flow of the Nile, though much less at its *maximum*, is more sustained, stately, and useful for irrigation than that of the Indus, which latter, with its more rapid transitions in magnitude of discharge, is more turbulent, unruly, erosive, and liable to change its course by sudden natural avulsion.

The ratio by volume of the water-borne sediment of the Nile to the water bearing it, is, on the average of the whole year 1/1200, and in the months of August and September about 1/530.

The corresponding figures for the Indus are, on the average of the whole year, 1/500, and in the month of August, 1/400.

These figures indicate more erosive currents in the Indus than in the Nile; and it is probable, at the same time, that the silt of the Indus is more sandy and less clayey less fertile in fact than that of the Nile.



L. Section of Proposed Rohri Canal offtaking from River Indus at Sukkur

PLATE V

Official Experts Silent on the Subject of Waterlogging

The subject of waterlogging has received scant attention from those responsible for the Sukkur Project (1920).

Almost the only reference to subsoil water levels in the Project, is the following reference to the Rohir Canal tract :—

"Very little irrigation from wells is practised, owing to great depth of subsoil water below ground level. Near the river this depth varies from 20 to 30 feet below ground. In the Jamrao tract it is from 20 to 35 feet; in Fuleli and Hyderabad from 30 to 50 feet. In Nasrat Canals district, except along the river banks, it is from 40 to 65 feet below ground."

The higher official authorities have been vague in their ideas on the subject. There was a conference of high officials held at Karachi on the 19th January, 1918, and at that conference, Sir. T. Ward, Inspector-General of Irrigation in India, spoke as follows ;—

"The (estimated) duty (of the water) must also be considered from the point of view of waterlogging. It is not possible, however, for me to give an opinion on this question. This must be left to people who know Sind conditions.'"

This left the responsibility with the Bombay-Sind officials. Another conference of officials was held at Government House, Karachi, on the 3rd February, 1919, under the presidency of the Commissioner. In the minutes of that conference the following is recorded ;

"Mr. Gebbie (Chief Engineer, Irrigation Works, Bombay) raises two points :

(*a*) Danger of waterlogging.

(*b*) Minimum discharge of the River Indus."

The conference then proceeded to discuss other matters, but avoided the subject of waterlogging.

The Sukkur Barrage Project (1920)

The River Indus in Upper Sind, as we have seen, flows on an elevated edge of soft alluvial soil, formed by deposits of silt from its own flood-spills. Buckley, in his excellent treatise, "The Irrigation Works of India," gives the following description :—

"Sind is an alluvial plain, almost every part of which has been swept by the Indus at some time or other. Traces of ancient channels are to be met with in every direction. The river has gradually worked its way from west to east. . . . The river more or less continually carries away its banks in one direction, and forms new land in another."

From time to time, during the past 70 years, projects for the control of the River Indus, for irrigation purposes, by means of a weir or barrage built across the river at Sukkur, have been mooted, considered, and rejected as unsatisfactory. All experts who have dealt with these projects in the past have been keenly apprehensive of the risk of the river's changing its course, and deserting the Sukkur gorge altogether as a consequence of any artificial obstruction offered to the river's flow there. The latest and best considered project was one prepared in the year 1910 by Dr. Summers, C.I.E. In this project, which was, however, ultimately negatived, on the advice of a committee of experts whom the Secretary of State for India consulted for the purpose, the site proposed for the barrage was at Bhakkar, just up-stream of the rocky gorge of Sukkur.

With a view of minimising obstruction to the river's flow, the level of the top of the gates of this barrage was fixed at 192 feet above mean sea level at Karachi.

The authors of the project of 1920 have been bolder (or rasher, as the case may be) than their predecessors. They propose to build the barrage at a site downstream of the gorge—about 3 miles downstream of the 1910 site—and to have the top of the gates at 194.5 feet above sea-level. They claim that the effect of the obstruction offered by the barrage to the flow of the river will not extend further upstream than the gorge; and that as the river is contained securely in high ground, between the gorge and the barrage-site, there can be no risk of the river abandoning its present channel by reason of interference with its flow through the barrage.

In this belief they are mistaken. They appear to have been associating afflux with the maximum flood only. But Fig. 1 shows that the effect of ponding-up to 194.5 at the barrage in the month of May will extend 16 miles up-stream of the barrage, and 13 miles up-stream of the gorge. This will cause shoaling up-stream of the gorge, which will obviously increase the risk of river-avulsion. See also, Fig. 2. The Barrage of the 1920 Project will interfere with and

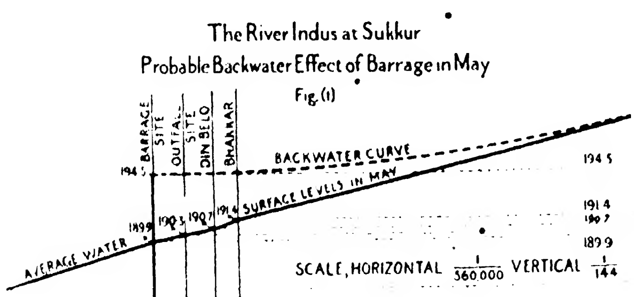


Fig. 1

obstruct the flow of the river throughout the flood season, except in the mouth of August. The authors of the 1920 project have probably been driven to this risky expedient as a consequence of their decision to include in the scope of their project the irrigation at present effected from the canals on the right bank of the river at, and below, Sukkur.

The water surface of the river *at Bhakkar* is, throughout the four months, June to September, at, or above, the level 194.5, *on the average*; and the authors of the 1920 project may have felt that they could not very well claim to be improving the condition of these canals, by means of the Barrage, unless they were able to claim that they would thereby be enabled to hold up the water to that level at all times, by means of the gates.

The fact that by holding up the river to the greatest practicable height, they were able, at the same time, to *increase the area* brought under flow by the North West Canal, as well as to *decrease the cost*, by reducing the depth of excavation of all the canals, no doubt helped to decide them to adopt that feature of design.

The mean annual discharge of the Indus at Sukkur, is about the same as that of the Nile at Aswan; but the mean monthly discharge of the former river is about 33 per cent. greater at the height of the flood season, than that of the latter river. The Indus is, moreover, a more turbulent and badly-behaved river than the Nile.

The barrage across the Nile at Assiut has a waterway 1832 feet wide, and it is designed to discharge the maximum flood under an afflux of five feet. The authors of the Sukkur Barrage Project (1920), in their endeavour to pass the maximum flood of the Indus (assumed to be 1,500,000 cusecs), with an afflux not exceeding one foot, have designed their Barrage with a waterway 3,960 feet wide, and floor at 176 feet above mean sea level. With this ample waterway they hope to escape the risk of the river changing its course, and deserting the Barrage on account of the obstruction to flow offered by it. But in dodging the Scylla of excessive afflux, they have drifted into the Charybdis of silt-trouble; which, in the end, will necessitate the creation of the excessive afflux which they have sought to obviate.

An Alternative to the Sukkur Project (1920)

Some one may be disposed to reply to these remarks: "This may be all very well, but it is only *destructive* criticism. Have you any constructive suggestions to offer? Can you suggest any alternative in preference to the Sukkur Barrage Project (1920)?"

To this the reply is in the affirmative.

I would have no Barrage at all, a Barrage being quite unnecessary and a needless and heavy item of expense. The Lower Swat River Canal, with Head at Abazai in the N.W. Frontier Province; the Upper Jehlam Canal, with Head at Mangla in the Punjab (or, rather, Kashmir); and the Trebeni Canal in Behar, are all examples of perennial canals which are fed from their parent rivers without the help of a barrage, or weir across the latter; and the same arrangement is practicable at Sukkur, on the Indus, in Sind.

Consider the case of the proposed Rohri Canal. The longitudinal section of the alignment of the first 80 miles, or so, of this Canal, is shown in Plate V. According to the Sukkur Project (1920), the gross area commanded by this canal would be 2,956,518 acres. I would arrange to irrigate about 60 per cent. of this area annually; or, say, 1,800,000 acres; half in each season, viz., 900,000 acres in the summer, and the same in winter.

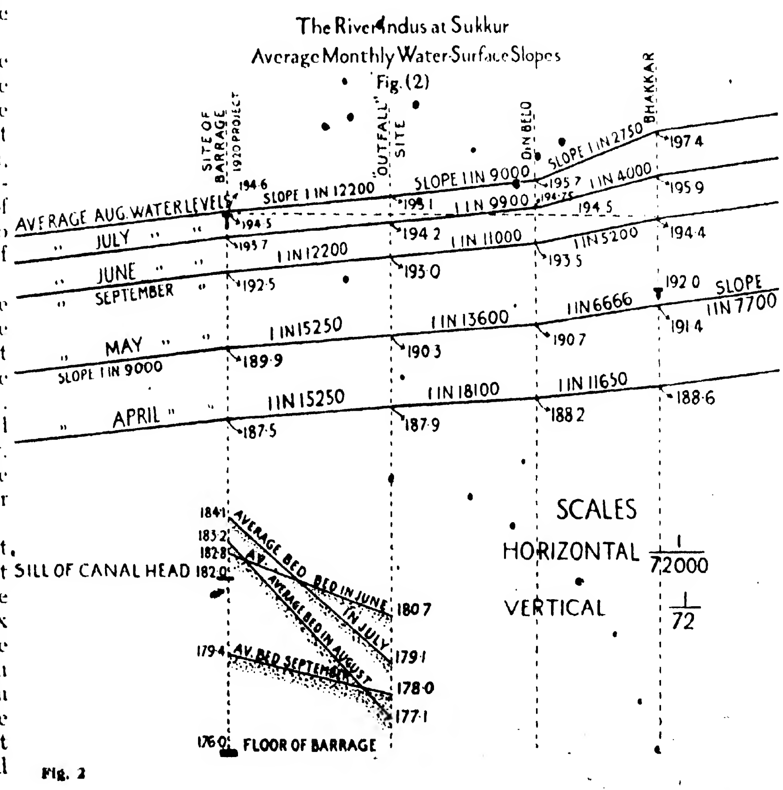


Fig. 2

In my scheme (without Barrage) it will probably not matter much at which site the Rohri Canal off takes, but I will take the least favourable condition by assuming that it will be at the lower site, where a winter water level of 186.8 on the average, in the sowing season, may be expected.

I would fix the full supply level of my canal at 186.0; so that its bed level, at head, would be 175.0. I would give the Head Regulator a waterway 800 feet wide.

The discharge per foot run of cill would be 13635/800 = 17 cusecs; and it would always be by "free" over-fall over the top of movable gate-cills.

The regulation of supply will be done by three tiers of gates in the summer, as shown in Fig. (6) above. The lowest gate will, in summer, always be resting on the floor of the Regulator; and the middle gate will also always be in the position shown, whenever the river water level is above 190.0. The top gate will pass down from above when required for use, and rise again from below, and the water will pass over its top by free overfall; and when the river is in high flood, above, say, 197.0., this gate will close the canal by abutting against a lintel at 196.0.

In the winter, all gates will be removed from the water, which will then flow into the canal, over the floor at 175.0.

Oil Refining in Great Britain

A brief description of the Anglo-Persian Oil Company's great refinery which has recently been established at Llandarcy, South Wales, for the treatment of imported mineral crude oil.

IT is not every day that a country, even a new one, sees the beginning of a new industry, and it is undoubtedly an experience for an old-established country such as Great Britain to witness a new development—and that of considerable magnitude—in connection with an important industry such as oil-refining. While it is true that, to a limited extent, oil-refining has been carried on for years past with Scottish shale, it is equally true to say that it was not until the Anglo-Persian Oil Company established a great refinery at Llandarcy, in South Wales (operated by the National Oil Refineries Limited), that oil-refining in Great Britain could be said to be a national enterprise.

The decision to establish an oil-refinery some six thousand miles away from the source of production was a somewhat revolutionary one, as it had previously been the almost universal rule for oil refiners to establish their plants as near to the source of supply as they could get convenient facilities for shipment to their consumers. But even at this early date—the refinery has only been actively working for a few months—the move is claimed to have fully justified itself. There are, of course, special considerations peculiar to the oil industry that make the refining of oil in Great Britain of particular national importance, but in this article we are not especially concerned with this aspect, the intention being rather to outline the scope of the establishment and show how the new industry has been developed.

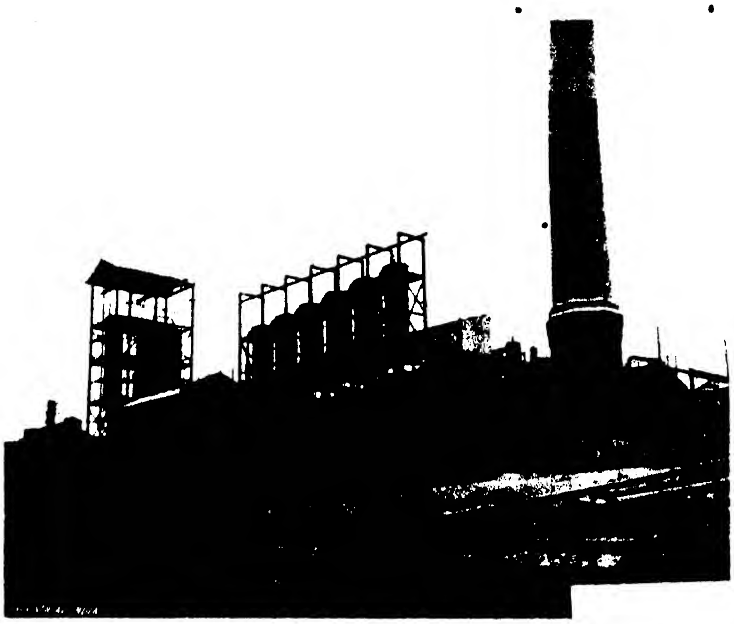
Before proceeding with the description, it may be added that the refinery was formally opened on June 29th, by the Right Hon. Stanley Baldwin, M.P., President of the Board of Trade, and that, together with a number of distinguished visitors, many press representatives attended to view the works, and to see the progress made in the new industry. Reference to the views expressed at the formal speeches will be made at a later stage in my contribution.

Initiation of the Enterprise

While the project for the creation of the refinery was part of the pre-war policy of the Anglo-Persian Oil Company, it was not until 1917, that the Company was able to obtain the desired property from the private owners and the Swansea Harbour Trust. Then, owing to war conditions, nothing could be done, so that it was February, 1919, when actual operations commenced. The undertaking has, therefore, been brought to its present stage in a little more than three years, and it represents an expenditure of three millions sterling. It may incidentally be remarked—further figures will be given later—that the refinery has a present capacity for a throughput of 2,000 tons of crude oil daily, and that an increase of 50 per cent. in capacity has already been decided upon.

The refinery site is situated in the neighbourhood of Skewen, and the first essential was the building of a spur line from the Great Western Railway. When operations commenced the area now occupied by the extensive plant and tank farm was a waste of rabbit warren and low-lying bogland. As soon as the plant began to take shape under the hands of the small army of workmen engaged, attention was paid to the building of a picturesque model village, which was given the name of Llandarcy to commemorate the late Mr. D'Arcy, to whose enterprise the Anglo-Persian Oil Company owes its Persian concessions. Next the construction of jetties for the oil-tankers at Swansea Harbour, the development of a subsidiary tank farm near the docks for oil in transit, and the laying in of the series of pipe lines to the main tank farm, about four miles distant, were proceeded with.

The plant commences with two storage tanks for oil fuel, situated close by the jetty at the harbour entrance, and so arranged that vessels can bunker without entering the



Crude Bench with preheating Apparatus

harbour. The main installation is, however, situated within the harbour, where one of the three docks, known as the Queen's Dock, has been allocated to the users of the refinery, and three jetties have been built (one in course of construction), for the accommodation of the oil tankers, which bring the crude oil from Persia. The vessels engaged in this traffic are owned by the British Tanker Company Limited, a subsidiary of the Anglo-Persian Oil Company, and the arrangements in vogue render it possible for three vessels both to berth and discharge, or load their respective cargoes simultaneously.

Berthing of Vessels

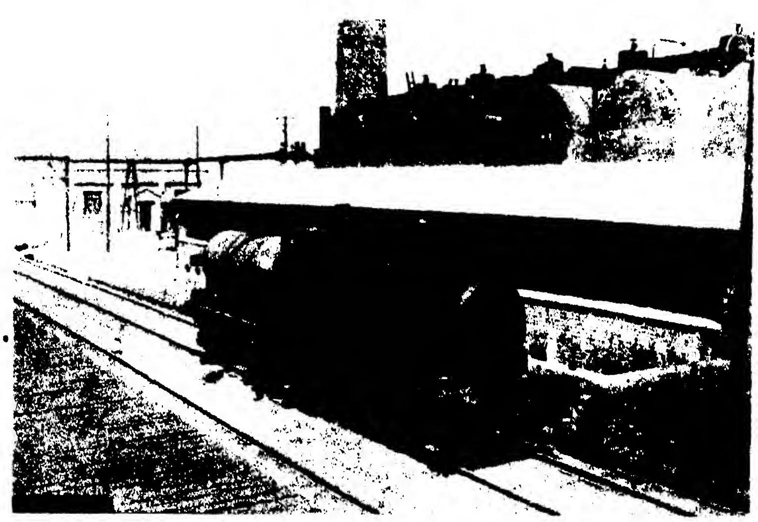
As soon as a vessel berths, its pumps are connected by flexible piping, with pipe-lines, which run from the berths to eight enormous transit tanks located on an area adjoining the docks. Six pipe-lines are provided, their size ranging from 8 to 12 ins. in diameter, two of them conveying crude oil from the ships and the remainder taking back the refined products which other vessels then carry to points along the coast or abroad. Each of the eight tanks to which reference has been made, is capable of storing 10,000 tons of oil, and this dock area, known as the "Transit Site," with aggregate storage capacity for 80,000 tons of oil, with a powerful pumping station and the series of pipe lines, has been designed to avoid any delay in the work of unloading or loading the tankers. The efficiency of the organisation is such that a 10,000 ton tanker can discharge its cargo into the tanks in, approximately, twelve hours, and a vessel of the same size taking away a cargo of refined products can load in about twenty hours.

From the transit tanks, powerful direct coupled centrifugal pumps, driven by electricity, deliver the crude oil to the main tank farm, adjoining the refinery, the distance from the tanks being about four miles. At this main farm there are 33 tanks, 25 of 10,000 tons capacity and 8 of 5,000 tons capacity, the larger tanks being for the storage of crude and fuel oil and the smaller ones for the storage of kerosene and petrol. The aggregate storage capacity of the main tank farm is something over 75,000,000 gallons, and the total length of the pipe lines, apart from those inside the refinery, is 34 miles.

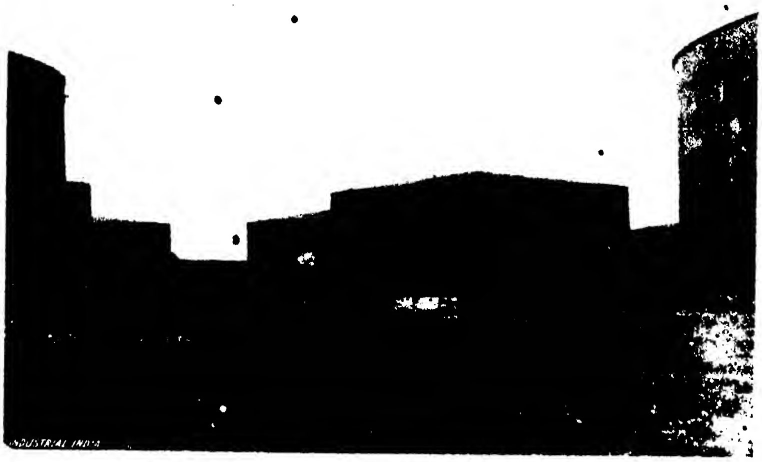
The Planning of the Refinery

In planning the refinery every advantage was taken of the knowledge gained from practical experience in other refineries throughout the world, and from the studies of the company's staff of research chemists, who have for years past been engaged in investigating the properties of Persian oil, with a view to securing the best results. The result is a plant embodying all the latest improvements and designed to give products of uniform quality, produced on the most economical basis possible. It is claimed that in lay-out, efficiency and economy of operation, this plant takes second place to no other of its kind in the world.

The general lay-out of the refinery will be seen from the accompanying plan. The buildings are located on the slope of a hill, which is surmounted by a water storage tank and a tall observation tower. A searchlight mounted on the latter enables observations to be made at night. The refinery area, tank farm and model village cover 650 acres of land, and all except the village is enclosed and



Lubricating Oil Bench with Fireless Locomotive in foreground



Section of Main Tank Farm

kept under guard by special police. As will be noted, the boiler house and power station are near the centre of the site. In the former there are six Thompson boilers—to be increased to eight when necessary—and in the latter are three turbo-alternators of 2,500 k.w. each, three-phase, 3,3 p.p. volts, running at 3,000 r.p.m. The turbines are by Messrs. James Howden and Company, and the alternators by the English Electric Company.

Special precautions are naturally taken against fire, and it may be noted that the locomotives used in connection with the traffic into and out of the refinery, are operated on bottled steam—from which they have fittingly been nicknamed " Thermos Flasks," by the employees. One of these locomotives is the subject of an illustration accompanying this article. Oil firing is generally used throughout the refinery, and a final reference to the plant may deal with the reservoir, which with a capacity of 13,000,000 gallons of water, supplies the cooling water required for the stills, the boilers and for other purposes.

The System of Distillation

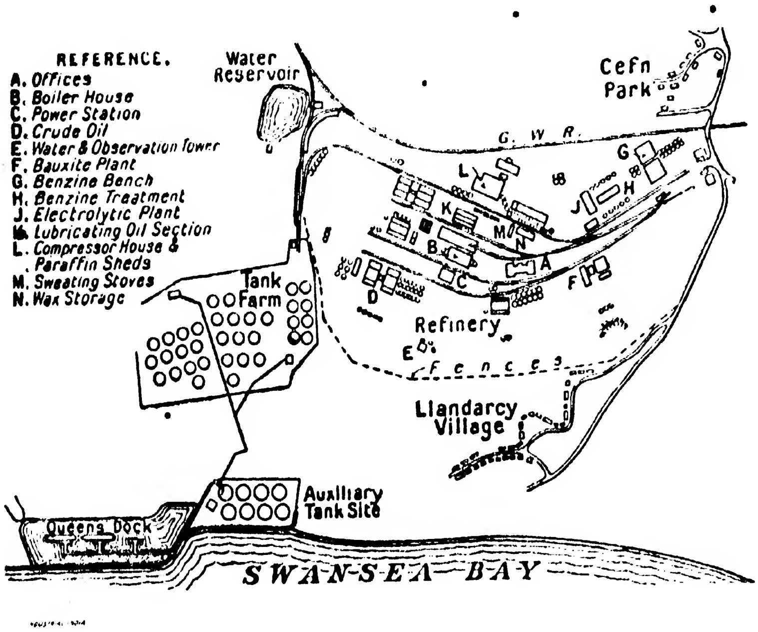
The refining of petroleum is a lengthy operation, consisting in the first place of a distillation process for separating the oil into the various fractions from which, later, the petrols, lamp oil, lubricants, etc., are made. This is followed by chemical treatment for the purification of the several distillates, and sometimes, as in the present instance, by refrigeration for the removal of the solid paraffins and the subsequent refining of these by a heating process known as sweating.

The continuous system of distillation is employed at Llandarcy for the first treatment of the crude oil, which passes through various units in a constant stream. The most volatile fractions, which form the basis of petrol and kerosene, are first separated; then the others in order of their volatility. Maximum economy of fuel is secured by the introduction of heat interchangers, these utilising the heat from the vapours of the stills, and from certain residues to raise the temperature of the cold oil entering the system.

From the tank farm the crude oil is pumped to the refinery, where it passes through the first distillation process mentioned above. Following the distillation from the crude oil stills, it is transferred to the benzine refinery and there agitated in an upright vessel, known as a washer, with a solution of caustic soda, being partially deodorised in the process. The distillate so treated is then passed to the benzine rectification stills, where it is split into such fractions as the market demands petrol and kerosene. Even at this stage the petrol has a fairly strong odour; it is therefore returned to the benzine refinery, where it receives its final treatment to remove sulphur and to deodorise it. In this process, the petrol is agitated with a solution prepared by electrolysis, this solution being prepared at the refinery in a special section of the plant. The kerosene undergoes a special filtration process through granular bauxite, prepared in a particular manner—and both the petrol and kerosene, now ready for the market, are transferred to their respective storage tanks ready for delivery either by tank wagons, or by vessel.

There are, of course, other processes, which we need not now consider. It might, however, be added as showing how carefully the work is supervised that nearly 1,000

Benzine Washers



Plan of Anglo-Persian Oil Co.'s Refinery at Llandarcy, South Wales

routine tests of oil, covering every stage of its progress through the refinery, are made each day by the laboratory experts, in order to ensure uniformity of product. The Company's main research laboratories are situated near London, but research facilities have also been provided at the refinery, and an interesting detail of the laboratory equipment is a self-contained unit, in which the experiments that promise success when carried out on a miniature scale with glass and test-tube are repeated in small working models.

The Formal Opening

As intimated previously, the President of the Board of Trade formally opened the new refinery on June 29th. In welcoming the distinguished visitor at a luncheon held subsequently, Sir Charles Greenway, Bart., Chairman of the Anglo-Persian Oil Company, said that since the works were opened in July, 1921, they had produced something like 500,000 tons of refined products. The Company was so well satisfied with the results that it had been decided to extend the capacity by 50 per cent., and orders had already been placed for the additional plant. He also mentioned that the Anglo-Persian Oil Company now gave employment to 60,000 men, 20,000 in Great Britain alone. He added that smaller plants were projected for Scotland, France and Australia.

Installation of Extensive Gas Works Plant

By BIRENDRA NATH DEY, B.Sc., A.M.Inst.C.E. etc.

(*Continued from page 64*)

Weeks Centre Valves

THE standard pattern with few alterations have been used. The two valves working Nos. 1 and 3 sets of boxes face opposite way to valves for Nos. 2 and 4 sets. The right and left handed valves have the main inlets on the same side of the building. In each valve there are four inlet and four outlet, also one main outlet and one main inlet sockets, all 24 in. diameter. Valve seats are specially made of renewable cast iron rings. The usual rubber washer between valve cap and seat has been deleted, so in closed position there is a machined metal to-metal contact. A special device has been added to the valve spindles to grind the valve cap on seat. This operation removes any grit or grease in the joint before tightening. The spindles are rising type and can be operated from the gangway level. Hand wheels are so grouped and marked that one box could be safely isolated. All valves are tested to twice the working pressure.

Water Seals

Adjacent to every inlet and outlet control valve a water seal has been provided for emergency use. These are cylindrical in shape and cast closed at top end with central division vane parallel to inlet or outlet flange. The vane reaches within two feet of the bottom flanged end. The valve can be filled with water through attached U pipe, to a height not exceeding the bottom of inlet or outlet gas pipes, and a sufficient waterseal is obtained. The water can be drawn out by a syphon fixed to valve body. The discharge due to additional fluid when the seal is in use, is visible for safety.

Liquor Drains

Malleable iron drains 2 in. diameter have been provided for the box floors, and gas mains at each inlet and outlet connection. Each box is sepatately connected to the seal pot by means of one main pipe, with gland cock and three branch pipes from box floor. The drain pipes from gas mains are also provided with gland cocks, and are separately connected to the pot with adequate water seal. At each change of direction in drain pipes, crosses and

plugs have been used for cleaning purposes. All pipes are laid to fall. Two seal pots embedded in ground are allotted for each set of four purifiers and one catch box. The discharge of liquor, which is visible, is disposed off through a 4 in. diameter cast iron underground drain extending the whole length of house.

Purifier and Catchboxes : Accessories

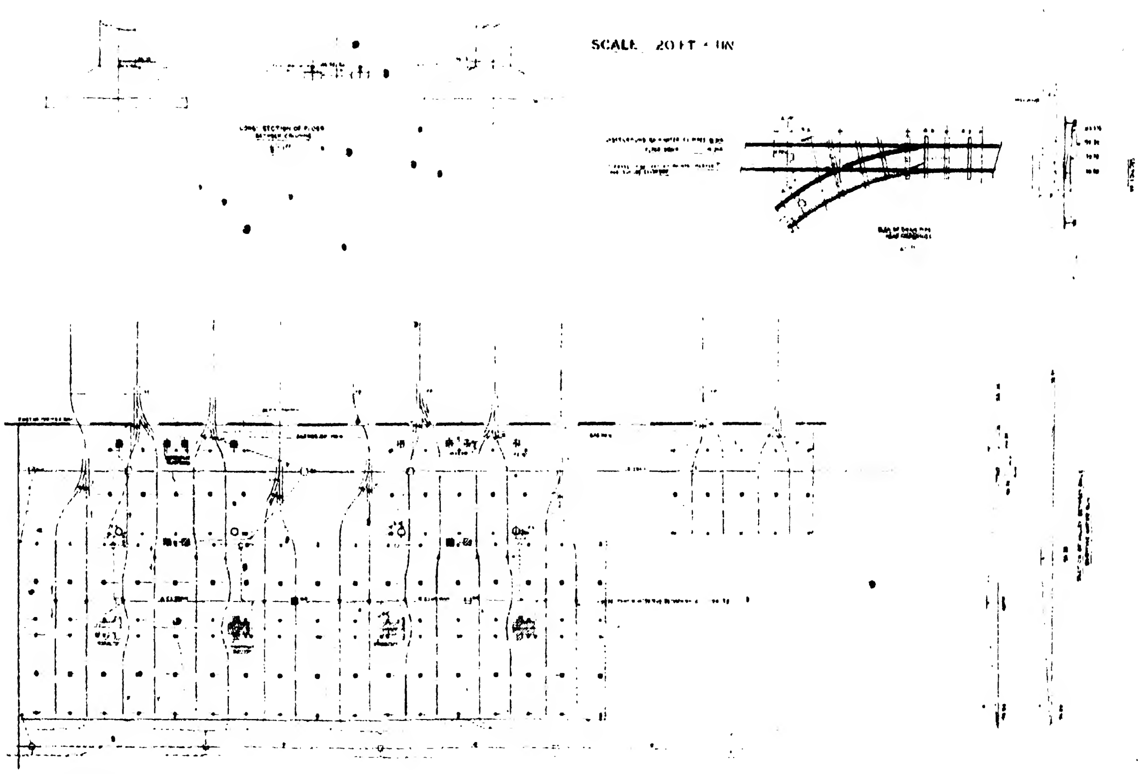
Concrete gangways are provided on top of box dividing the area into four equal parts, and forming supports for steel covers. Inside the boxes there are concrete ledges and cast iron pockets fixed on walls and columns to support light built up girders on which wooden grids rest. Lattice girders have been used in preference to rolled steel joists, as the former allows better circulation of gas. Provision has been made for two tiers of grids each carrying ten inches of oxide. Grids are about 3 ft. 6 in. by 2 ft. 6 in. overall size, and composed of wedge section larch laths and substantial oak side members all tied together by long steel bolts. The floor of each box has four 18 in. diameter collars, embedded gas tight in concrete, two of the same forming inlet and other two outlet holes for gas. These holes are placed as far apart from each other as possible, thus offering maximum surface of oxide in the passage of gas from inlet to outlet. The inlet collars have five feet high extension pieces bolted on. The incoming gas is discharged at the top of box and has to pass through layers of oxide to reach the outlets at floor level. There are four oxide discharge valves in each box placed central to the four covers. Valve plugs are made of sheet steel with lifting ring on top and cast iron base. Valve seats are embedded gas-tight in floor. The joint between the plug base and valve seat is machined, and the plug is securely clamped. The clamps are operated from the underside of box. When necessary the plugs can be lifted and the spent oxide discharged through holes into bogeys on ground level.

Railway lines 2 ft. 6 in. gauge with necessary points and crossings have been laid on the ground level following the centres of the eighty-eight oxide discharge holes. Bogeys collecting the discharged spent oxide are emptied into standard waggons, which remove the material back to the oxide store to be disintegrated, and revived for further use.

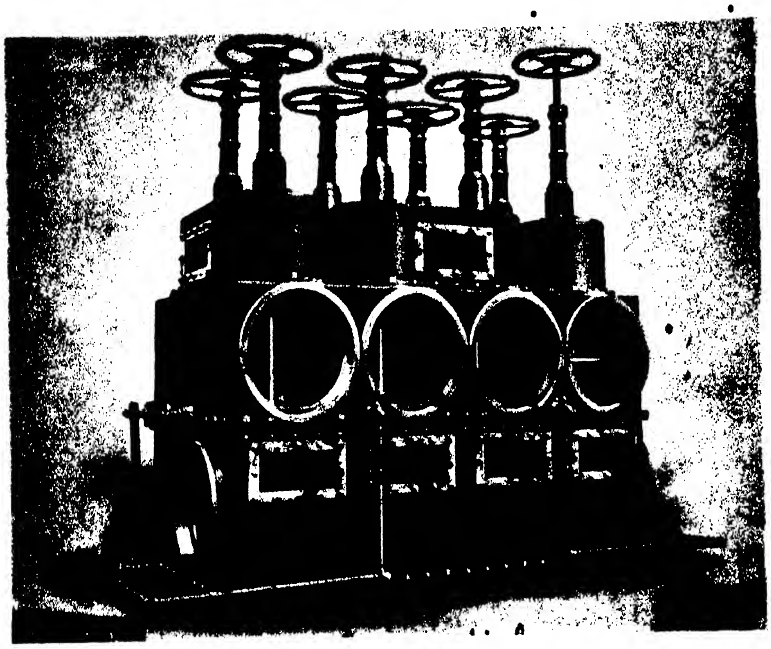
In purifier house there are five lines of runways 325 feet long, fixed to the underside of revivifying floor beams, and in catch boxes six lines 80 feet long bolted to the roof trusses. The runways are placed overhead to the centre line of covers and oxide plugs, and are provided with Herbert Morris type gear driven trolley, and 2-ton lifting blocks.

Steam Heating Pipe

A steam main varying from 3 in. to 1½ in. diameter, from east end of the plant is laid the whole length of the purifier supported on rolled steel bearers. The main branches out at three points. At each point a full way stop valve, Royle's reducing valve, to reduce pressure from 160 lbs. to 16 lbs., safety valve set at 16 lbs. per square inch complete with dial pressure gauge, all valves 1½ in. diameter have been installed. These



Plan and Sections of Ground Floor



Weeks' Centre Valves

valves are all supported on wooden platforms and are under the gangway safe from unauthorised handling. Each 1½ in. diameter branch is subdivided into ½ in. diameter branches, which are connected to a group of eight purifier and two catchboxes with ½ in. globe valve on each connection. Inside the boxes 4 in. diameter cast iron heating pipes are suspended in the shape of one loop rectangular coil. Each arm of the coil is laid to fall towards the outlet, and rest on roller brackets to allow expansion. The inlet and outlet ends are properly anchored. Condensate from each coil is drained through a syphonia steam trap placed on the ground floor.

Water Supply

A 6 in. water main from the west end of the building is provided for the whole length. The main is supported on steel beams and runs parallel and adjacent to the steam main. A 6 in. sluice valve at each end, and 1 in. air cock and 2 in. drain cock screwed steam are fitted to the water main. Five equally spaced 4 in. diameter vertical branches are taken off the main. These branches are provided with 3 in. hose connections at purifier gangway, and revivifying floor. The water main is protected from frost by lagging and heat from steam main.

(To be continued)

Mouldable Wood

PLASTIC WOOD is the name given to the latest accessory for the use of pattern makers, and is manufactured by Necol Industrial Collodions Limited, a Constituent Company of Nobel Industries Limited.

The adaptation of it can be visualised when it is stated that Plastic Wood when first taken from its container is mouldable to any form, yet in a few hours it sets so hard that although lighter in weight, it has all the characteristics of wood with one important exception, it will not absorb moisture. When set hard it can be worked with the usual joiners or carpenters tools, and nails, screws, etc., can be driven into it without fear of splits occurring.

This substance undoubtedly supplies a long felt want in the engineering and foundry trades. Its use in the woodworking trades, furniture manufacture and so forth, has already been proved. There is no doubt that in any sphere of manufacture where filling, building up and repair work of various kinds are carried out, Necol Plastic Wood will find its place as an accessory.

The manufacture of Plastic Wood is a complicated process, and it is only after most careful experiments that it has been at last perfected. Instantaneous success is predicted for the marketing of this product which has already in the past six months quadrupled its sales.

It is not expensive the retail price being about 2s. 6d. per lb. according to quantity.

Further information concerning this unique product can be obtained on application to the Manufacturers, Necol Industrial Collodions Limited, 62 London Wall, E.C.2.

Sugar Machinery

We propose in a short series of articles to deal with recent developments in the machinery used in every branch of the Sugar Industry, and in this, our first article, we are dealing with the Sugar Industry in an introductory manner, recording a number of salient points which were brought out in the report of the Indian Industrial Commissioner.

ACCORDING to historical records the art of preparing sugar from cane originally came from India, and it seems to be generally supposed that India is actually the original home of the sugar cane, at all events, this country is credited with making the first efforts in the evaporation of the juice to a solid substance.

During the years which have elapsed since these early days, the sugar production of India has grown enormously, and this country is now one of the largest producers of sugar in the whole world, and by far and away the largest producer of any section of the British Empire.

The following extract taken from Mr. Thomas M. Ainscough's general review of last year, gives the position up-to-date as regards India's acreage in sugar, and the actual figures for production.

" The estimated total area under sugar cane in 1919-20, was 2,647,000 acres, and the estimated yield 2,992,000 tons. The average yield of Gur (unrefined sugar) was 2,531 lbs. per acre, as compared with 1,903 lbs. in 1918-19, and 2,310 lbs., the average of the preceding ten years. Before the war India imported annually some 900,000 tons of sugar. In 1919-20 the imports were 408,700 tons, at very high prices. In spite of this reduction in imports and high prices, the area under sugar cane in India did not expand, owing probably to the lack of capital to obtain extra labour, and to provide manure and irrigation. The Indian Sugar Committee recently investigated the whole question very thoroughly, and the Indian Sugar Corporation has recently been floated in India, with a capital of five crores of rupees in order to extend the cultivation on a large commercial scale. In the meantime, the Government of India have established a sugar bureau at Pusa, with the object of furnishing advice to cultivators, manufacturers and others. The bureau is in touch with nearly all the sugar experimental stations in the world, and also with the principal sugar machinery manufacturers in the United Kingdom and United States of America, and has collected a mass of valuable information with regard to the industry."

The above figures show very clearly the need for expanding the sugar industry of India, and we propose to outline some of the principle points, which have been investigated as to how this industry may be developed.

A Pioneer Sugar Factory

On this point it is of interest to record that a pioneer sugar factory has been decided upon to be erected in South Bihar, but unfortunately owing to the high prices of machinery the scheme may not materialise until next year. However, the scheme has been accepted by the Legislative Council at a total cost of R's 4 lakhs.

Dealing with this enterprise in the February Issue of the " Journal of Indian Industries and Labour," the following extract appears ;

" If sugar manufacture by modern methods is to be introduced into this area, it will be necessary for Government to pioneer the industry. Further, if sugar manufacture is to form an outlet for Indian enterprise, it is desirable, if possible, that factories should be started on a smaller scale than those recommended by the Indian Sugar Committee. After careful consideration, therefore, and discussion with Mr. Hulme, late Sugar Engineer to the United Provinces Government, and Mr. Wynne Sayer, Secretary of the Indian Sugar Bureau, it has been proposed that Government itself should put down a sugar plant of the most up-to-date type, capable of crushing 50 tons a day, at some suitable centre in South Bihar. Such a factory will, it is hoped, attain the three following objects ;

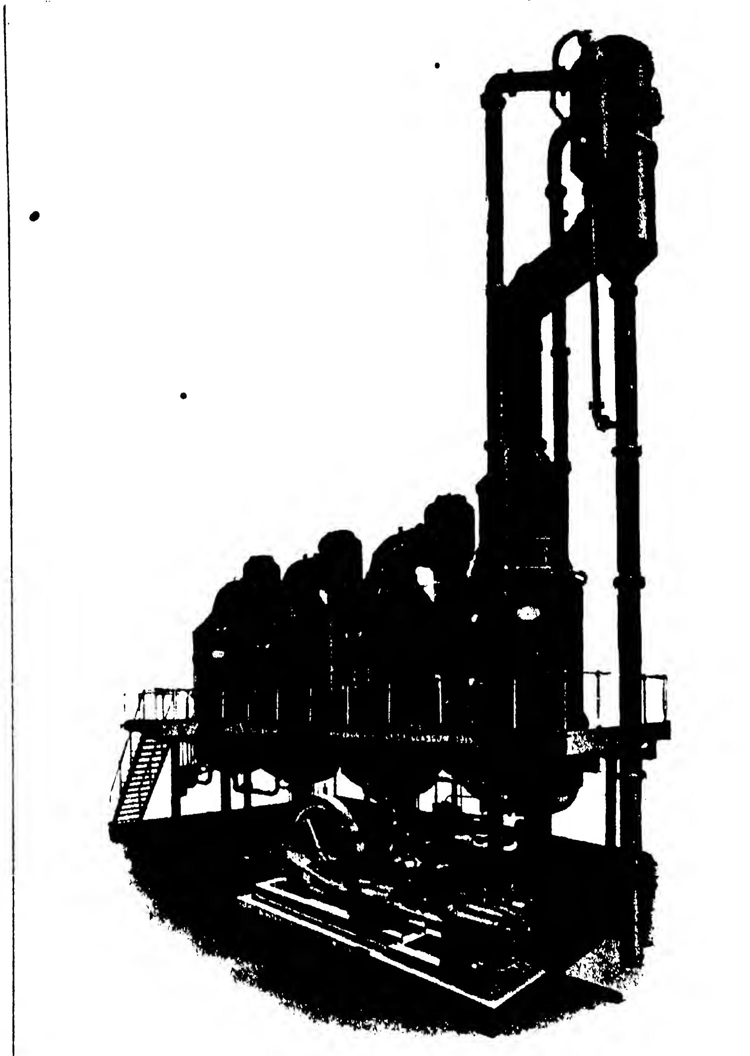
(1) The question whether a plant, which represents about the economic limits in small plants, can compete with larger plants will be settled.
(2) The system of the free sale of cane to central factories by cultivators will be introduced into South Bihar and can be gradually extended ; and
(3) A station will be available in which Indians can be trained in the chemistry and engineering of sugar manufacture."

We propose now to deal with a number of points raised in the report of the Indian Industrial Commission, which states the position of the industry in a very clear and concise manner.

Referring to the imports of sugar it is pointed out that during the war the fall in the volume of imports was exactly counterbalanced by the rise in prices, and from this it would seem that India is able to spend about 10 millions sterling a year on sugar, which may be regarded somewhat in the nature of a luxury, and that for her ordinary dietary gur is sufficient.

We would like on this point to emphasise, what seems to us a very excellent example of showing the need for modern methods, and it would appear that the present crude methods of reducing the cane to a commercial product, is quite incapable of producing further revenue, and not until more scientific methods are adopted on the agriculture side, and modern methods on the mechanical side will revenue be increased by greater output, and at the same time reduce the present great expenditure on the imported product.

Dealing with the improvements which have been carried out on the agricultural side in the different provinces the Commission's Report finds that in Madras considerable



Evaporator — *Harvey Engineering Co. Ltd.*

improvements have been effected by the liberal introduction of diseased-proof cane, with the result of arresting the decline of the cane area in the deltaic tracts. Improved methods of cultivation have also led to an increase in the area under cane.

In the Bombay district Mr. Keatinge, the Director of Agriculture, anticipates that out of the areas in Bombay over which irrigation is now extended, some 80,000 acres are likely to be planted with cane. The Agricultural Department, by an application of water and manure in quantities actually less than those given by the local growers, secured a crop in 1915-16 of 50 tons of cane yielding 6 tons of gur per acre. The use of ammonium sulphate together with oil cake in addition to farmyard manure was found to be the most economical form of fertiliser.

In the North West Frontier Province, although situated in the extreme North West corner of India, and exposed to bitter frost in the cold weather, sugarcane is grown in this district under irrigation from river channels, on an area of 31,000 acres, and a yield of over 2 tons of gur is obtained from an average crop of 28 tons per acre.

The Agricultural Department has for some years past conducted experiments with a view to introducing a modern factory system of cultivation and manufacture, and the results indicate that the prospects of success justify the establishment of an experimental Government factory, which could be developed into a large concern drawing its supplies from a maximum area of 5,000 acres.

The interesting suggestion is also made that the prospects of beet sugar cultivation have been investigated, with almost equally favourable results, and it has been suggested that a central factory could obtain supplies of both cane and beet, which would enable it to operate for between seven and eight months in the year.

This appears to us as a very interesting proposition, because it opens up possibilities of operating the factory plant during a longer number of hours in the year, thus making a sounder commercial proposition, and on this point it is also of interest to note, that prominence is given to the importance of oil cake as a manure, and this again opens up an important outlet for industrial developments, as given an immediate market for a by product of the Oil Mill.

The Commission's Report emphasised the shortage of farm-yard manure, and points out that land in Bombay, heavily manured with oil cake and well cultivated, gave the most economical results when used with ammonium sulphate.

Another opening for industrial development with the increase of sugar out-put on modern lines, would be the developing of the actual manufacture of confectionery, and it would seem only a question of putting the sugar industry on a sound economical basis for this development to take place.

Turning now to the machinery side of the question, it is with this section that we are primarily concerned at the moment. The subject would conveniently divide itself into two sections, namely :—The regular factory system as ordinarily understood; and the small plant worked with a small prime mover, such as an oil engine.

There is no clear dividing line between these two propositions at present, as will be clear from the extract quoted above from the "Journal of Indian Industries and Labour." There can, however, be no question as to the economic value of using machinery, which would be power driven, in place of the existing more crude methods.

Fertilizing

The Commission points out that the cost of management is a factor of some importance, and small Indian central factories should be able, in this respect, to hold their own

against the somewhat expensive control of the larger factories. At the present time the lower limit of the factory system seems to be a mill capable of dealing with 250 tons of cane per day, or with the produce of an area of 25 acres in the North of India, or of 10 to 12 acres in the South. Assuming a working season of 100 days, the smallest central mill will require 2,500 acres of cane in the North of India, and from 1,000 to 1,200 in the south. Only in a few places can such large areas be secured, and it is urgently necessary to encourage concentration of sugar-growing as much as possible, simultaneously with the technical development of sugar manufacture on a small scale.

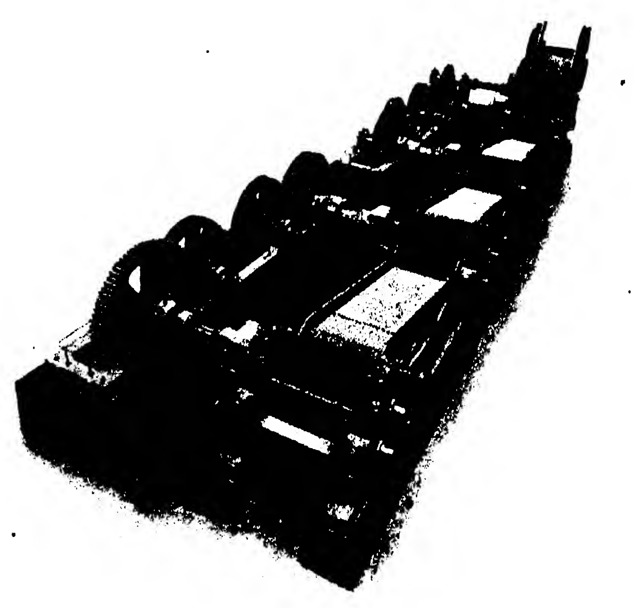
Another factor that has to be taken into account is the lack of available bullock power for crushing cane. It should be remembered that by far the greatest portion of Indian cane is made into gur, the cane being crushed in bullock mills, and the juice boiled by the cultivator himself. As a rule, the cattle power is insufficient to deal economically with the cane grown. The cattle are overworked and weakened by the hard toil of the mill, following on the continuous ploughing of the monsoon and the rabi sowings. The temptation to the cultivator to slack off the mill, with much resultant loss in extraction, is great. Again the crushing season is often prolonged till the canes have deteriorated. One or more of these conditions are usually to be found in all areas where cane is grown to any considerable extent. It is manifest, therefore, that the expansion of cane growing, in the absence of a central factory, will be held up unless some suitable means of crushing cane, otherwise than by bullock power, can be devised. The replacement of cattle by mechanical power, however, will further accentuate the shortage of farm-yard manure, to which we have already alluded, and render the necessity of artificial manures more urgent.

The original form of cane mill in India, was the old stone pestle and mortar, revolved by bullock power, with an extraction of about 33 per cent. in its most primitive form. This type has now almost disappeared. The mill with wooden rollers was an improvement on it, but worked very heavily, with much strain on the bullocks; it gave an extraction of about 50 per cent. Various types of iron mills have now for the most part superseded both, and these are sometimes purchased by the cultivator, but are also often hired out by firms, especially those in Northern India, and Bengal, at so much a day, the cultivator finding the bullocks and labour.

The highest extraction that can be effected by the best type of bullock-driven mills, is about 68 per cent., or in the case of one or two types 70 per cent. This high rate can only be obtained from thick cane, and can only be maintained by the use of good bullocks regularly relieved. Under similar conditions, about 62 per cent. might be obtained from medium-sized canes, such as the sarathi grown in the United Provinces. From 50 to 60 per cent. extraction is effected by the less efficient types of mill, according to the class of cane crushed, the number of rollers and their setting. A two-roller mill gives about 56 per cent., under the most favourable conditions; but it must be remembered, first, that a cultivator has by no means always enough cattle to work his mill up to its highest extraction capacity, and is often tempted to slack the setting of his rollers to enable the mill to work faster. The result is that he burns under his evaporating pans one-third of the sugar he produces, to turn the other two-thirds into gur. In the next place, the rollers are not usually of hardened metal, and get worn more in the middle than at the ends. This also causes much waste of juice.

The real remedy is obviously to introduce power-crushing plant of sizes suitable to the cane area available, and to the purchasing power and technical skill of the people. The success of such mills, in the comparatively few instances in which they have been tried, has resulted in a tendency to concentrate cane growing in their neighbourhood.

There is a very great difference between the rate of working of power and bullock mills. The results of comparative trials at Poona, showed that a three-roller mill, with rollers 20 in. by 14 in., driven by an oil engine, could crush 4,500 lbs. of cane an hour, against 750 lbs. with a four-bullock mill, and 450 lbs. with a two bullock mill. Experiments in the South of India with three-roller mills of horizontal type, with rollers twelve inches in diameter, and eighteen inches in length, driven by oil or gas engines, have conclusively shown that they can on an average extract 15 per cent. more juice from the cane than is usual with bullock mills. Such mills require about 6 B.H.P. to



Crushing Plant — *Harvey Engineering Co. Ltd.*

drive them; they can deal with from a ton to a ton-and-a-half of cane per hour, and extract sufficient juice to yield from 200 to 250 lbs. of gur per hour. Under favourable conditions, the out-put of such mills will rise to 300 pounds of gur per hour. Roughly, their rate of out turn is equal to that of six pairs of cattle working six bullock mills. As they can be driven almost continuously day and night through the working season, these power plants will do as much work as 24 to 30 pairs of bullocks, and bullocks can only be worked from five to six hours a day each without causing undue deterioration. Evidence is forthcoming to show that such power driven mills can economically replace cattle for areas as small as 40 or 50 acres, and that even smaller types of power driven mills can be advantageously employed for areas as low perhaps as 25 acres.

Where these small power-driven mills have been introduced, it has been definitely established that they have increased the value of the product from a given area of land by from 25 to 30 per cent. Part of this is due to the fact that the increased milling power enables the crop to be handled at exactly the time when the sucrose contents are greatest.

In conclusion we would like to record the suggestion which is emphasised in the Commission's Report, where it says, in reference to encouraging the development of power plants that the ideal method is to form co-operative societies among the growers of the cane, who will employ qualified experts to run the plants. This proposition appears to us, under present Indian conditions, to be a very sound policy for putting into immediate operation. We have emphasised in this very brief introductory article the need for adopting modern methods and plant, and the co-operative system would appear to offer a practical means whereby power driven machinery could be adopted in cases where capital would otherwise not be available.

(To be continued).

The World's Shipping

Country.	June, 1914. Tons gross.	June, 1922. Tons gross.	Difference between 1922 and 1914. Tons gross.
United Kingdom	18,877,000	19,053,000	+ 176,000
British Dominions	1,407,000	2,201,000	+ 794,000
America (U.S.)...	1,837,000	12,506,000	+ 10,669,000
Austria Hungary	1,052,000	Nil.	—
Denmark	768,000	944,000	+ 176,000
France	1,918,000	3,303,000	+ 1,385,000
Germany	5,098,000	1,783,000	− 3,315,000
Greece	820,000	653,000	− 167,000
Holland...	1,471,000	2,613,000	+ 1,142,000
Italy	1,428,000	2,600,000	+ 1,172,000
Japan	1,642,000	3,325,000	+ 1,683,000
Norway	1,923,000	2,337,000	+ 414,000
Spain	883,000	1,187,000	+ 304,000
Sweden	992,000	996,000	+ 4,000
Other Countries	2,398,000	3,301,000	+ 903,000
Total Abroad	23,637,000	37,749,000	+ 14,112,000
World's Total	42,514,000	56,802,000	+ 14,288,000

THE 1922-23 edition of "Lloyd's Register Book," shows more than 28¾ million tons of shipping classed by Lloyd's Register. Excluding vessels of less than 100 tons there are recorded 2,680 sailing vessels of 3,027,834 tons, and 29,255 steamers and motor vessels of 61,342,952 tons, making a world total of 33,935 vessels of 64,370,786 tons gross. The book is also of especial interest as showing the position in 1922, as compared with the pre-war year of 1913, and in the following list the sea going steel and iron steamers and motor vessels owned by the principal maritime countries are included.

The countries in which the largest increases have taken place during the last twelve months are as follows:—Germany, 1,131,000 tons; Holland, 409,000 tons; British Dominions, 258,000 tons; Japan, 232,000 tons; and Italy, 231,000 tons. An analysis of the vessels entered in the special list shows that, whereas in 1914, there were in existence only 385 steamers for the carriage of petroleum in bulk, with a total tonnage of 1,479,000 tons, the present edition of the book includes 977 steamers and motor vessels, of 5,057,000 tons, for that trade an increase of 242 per cent. in the tonnage. The number of vessels fitted with internal combustion engines has increased enormously since 1914, at which date there were no more than 290 such vessels, of 234,000 tons recorded in the register. The total figures to-day are 1,639, of 1,511,000 tons, including 149 vessels of over 3,000 tons each, with a total tonnage of 848,000. Great development has also taken place with regard to the use of liquid fuel on board steamers, and it is an interesting sidelight on the present position to note that, whereas in 1914, 89 per cent. of the tonnage of the Merchant Marine depended upon coal, to-day only 70.6 per cent. is in that position. It may be added that the statistical tables for the year include, among others, a new table showing for various countries of the world the number of steam and motor vessels according to certain divisions of gross tonnage and according to certain divisions of age. Another interesting point is the number of new vessels owned in some countries. For instance, 63 per cent. of the seagoing vessels of the United States has been built within the last five years, while Japan has a percentage of 40, to the 33⅓ of France and Holland, and a little over 30 in the case of Germany, Belgium and Denmark.

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

Low Temperature Carbonisation (vi)

(THE "TOZER" PROCESS.)

BY DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min.E., Mem. Am. Soc. M.E., A.I.Mech.E., etc.

THE "Tozer" process, the work of Mr. C. W. Tozer, A.M.I.Mech.E., 66 Victoria Street, Westminster, London, S.W. 1., consists in simple and direct carbonisation of the coal in special retorts at 900-1,000 deg.F., with the usual complete by-product recovery plant.

The essential portion of the plant is the "Tozer" patent retort, which is specially adapted for the production of hard smokeless low temperature fuel for household purposes. Mr. Tozer is of the opinion, based on a very long experience of coal carbonisation, that the only way to obtain a dense and hard low temperature fuel, which will travel as well as coal without breaking up and forming an excessive amount of breeze, is to carry out quick carbonisation in a retort, so that the softened and swelling coal is confined and subjected to pressure, the pasty mass in this way being compressed to a homogeneous product, whilst at the same time arrangements must be made to take away very rapidly the gaseous and volatile products of carbonisation.

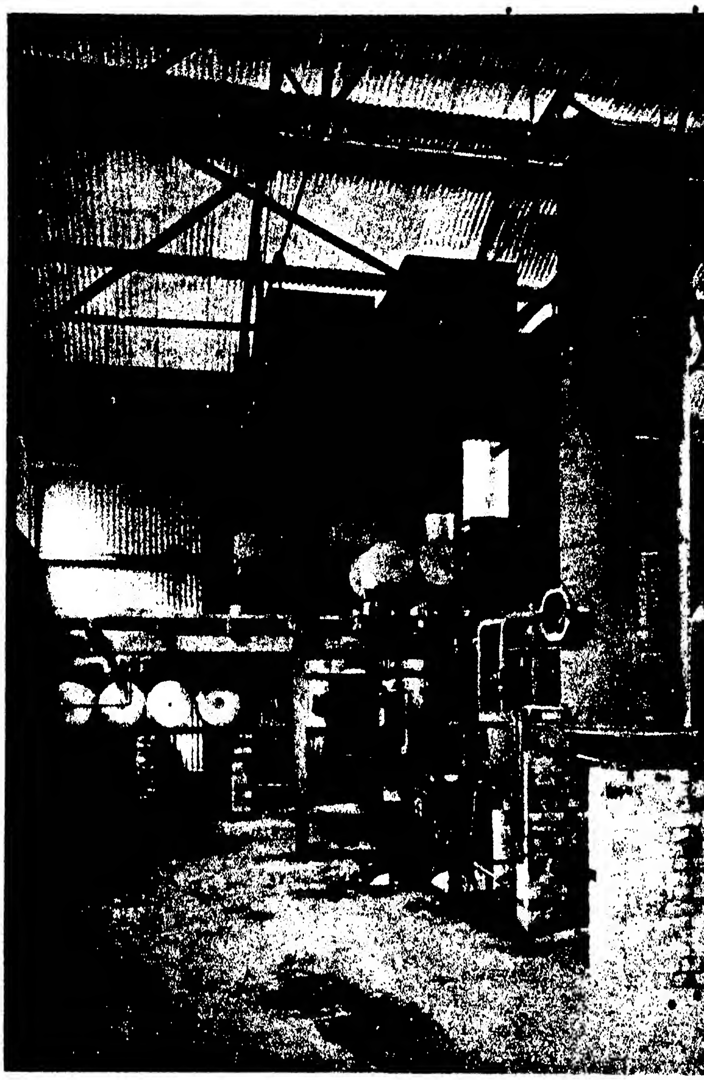
The principle of the "Tozer" retort is to carbonise the coal in long, narrow, vertical cast iron pipes, or tubes heated with producer gas, which will stand easily the pressure of the swelling coal. Very many different retorts have been constructed by Mr. Tozer on this principle, commencing at 10 in. diameter tubes. The trouble has always been with a simple tube that the bad conductivity of the coal means a long period of carbonisation to get a homogeneous product. The diameter of the tubes was reduced to get over this trouble, and finally a retort was constructed with 4½-5 in. sections, in which the carbonisation was completed in 4-4½ hours at 1,000 deg. F.

The principle of the modern "Tozer" retort, which, it is claimed, has finally got over the difficulties, is illustrated in the drawing and photographs. It is constructed of cast iron in the form of a double circle or annulus, one circle being concentrically within the other, the annuli being divided into vertical cells, or sections, by cast iron ribs, so that the heat is freely conducted from the outside of the retort, heated as usual by producer gas, or the rich gas given off during the carbonisation, to the inner sections. The small central circular chamber is kept empty, and acts as a gas passage connecting the upper and lower end of the retort. The coal is broken up roughly into pieces not exceeding 3 in. cube, and filled into the concentric spaces of the retort, forming therefore 8 vertical layers of coal. The retort is then heated to 900-1,000 deg.F., for 4-4½ hours. The maximum period of expansion is after about 3½ hours carbonising, but subsequently, when the heat has penetrated right to the centre of the coal, there is a certain amount of shrinkage, which assists in the discharge of the low temperature fuel. As evidence of the pressure to which the fuel has been subjected, the slabs when withdrawn are generally found to be brightly polished by the contact with the sides of the retort. As already stated, the top and bottom of the retort are in contact by means of the small central circular chamber in the retort. The whole retort is enclosed and subjected to a comparatively high suction, about 20 in. W.G., by means of a fan. One of the great advantages of a cast iron retort is that it is perfectly gas-tight, quite unlike firebrick retorts, and, in fact, many of the original "Tozer" retorts were worked quite satisfactorily at high vacuum. This is now found, however, to be unnecessary, and enables an exhauster to be used instead of a vacuum pump.

The special design of the retort and the strong suction maintained enables the volatile products to get away from the carbonising mass in a remarkably short space of time. These products are evolved in two directions at once, both from the top and the bottom, so that in actual practice the volatile products have to pass through a layer of only 5 feet deep, since the total depth of the retort is 10 feet, and half the products pass out of the top of the retort, and the other half out of the bottom, in addition to the advantage of having a very high suction impossible with any firebrick retort. This arrangement has two advantages, first, as already stated, that by removing the gases evolved almost simultaneously undue "cracking" of valuable volatile products is avoided, and secondly — even more important — that excessive pressure does not develop in the retort. Undoubtedly a great deal of the serious trouble experienced in this connection with low temperature carbonisation is due to the normal pressure of the swelling pasty mass of coal being aggravated by the evolution of gaseous and liquid products, which cannot get away fast enough, resulting in the retorts being completely jammed up. The design of the "Tozer" retort with an outlet at both the top and bottom of the retort, and a connecting passage, all under high suction, is claimed to have got over this difficulty entirely.

Retort Construction

To facilitate the discharge of the residual fuel through doors at the bottom, the retorts are made slightly tapering, and no difficulty is stated to be experienced in discharging. If the coal used is of a coking nature, the slabs come out intact 10 feet long, the full size of the sectional chambers of the retort, but if the



Gas Scrubbing and Washing Plant

coal is entirely non-coking, then the low temperature fuel is in the same physical condition as the original coal. It may be stated that this retort will carbonise any carbonaceous material, coal, lignite, shale, and peat, whether coking or non-coking, and in any size from dust to 3 in. cubes.

With regard to the wear and tear and distortion of the cast iron retorts, Mr. Tozer says that this is nil, because in the first place undue pressure does not take place, for the reasons already stated, and secondly, because of the shape, and the fact that the retorts are free to expand in every direction. The photographs show part of an experimental plant in London which consists of 6 retorts, handling a charge of 5 cwt. of coal per retort. These have been in more or less constant use for 6 years, and are stated to show no sign of deterioration.

A very large "Tozer" plant is at present being erected at Ballengeich, Natal, for the South African Carbide and By-products Co. The complete installation consists of a gas producer plant, electric power station, and a plant for the manufacture of carbide, in addition to the "Tozer" low temperature installation. The method of working on this particular installation is to first submit the coal to low temperature carbonisation to recover the valuable by-products, and then to gasify completely the residual low temperature fuel, using the gas for the production of electric power, by means of gas fired boilers and steam generation, for the manufacture of carbide.

The coal is delivered by wagons running on a narrow gauge (3 ft. 6 in.) railway from the pits to an elevator plant, and elevated to large overhead coal bunkers, with a capacity of 175 tons.

The carbonising plant consists of 24 "Tozer" retorts, with a total capacity of 120 tons of coal per 24 hours. The dimensions of the complete bench being 75 feet long, 17 feet wide, and 23 feet high, carried by sole plates to which the locking and operating gear for the bottom covers is attached, the whole installation resting on joists and stanchions.

The setting is of the regenerative type, the hot exit gases—after heating the retorts—passing through a series of flues containing chequered bricks, which absorb a large portion of the sensible heat, which is subsequently imparted to the secondary air supply, as usual. The heating medium is to consist of a mixture of producer gas and the gas evolved by the low temperature carbonisation of the coal, but, of course, can be producer gas only if necessary. The overhead storage bunker has two discharge chutes, which deliver the coal as required into hopper type charging wagons, which run along the top of the retorts on a narrow (36 in.) gauge.

The retorts are 12 ft. 0 in. high, and approximately 40 in. across, the charge being 25 cwt. (for the 8 sections). The complete retort bench is housed in a steel building 88 feet long, 32 feet wide, and 34 feet high (to the eaves), and the residual low temperature fuel is discharged on to a sloping hearth underneath the retorts, and raked down into a conveyor, and delivered to storage dumps. All the gases evolved are collected in one main, which is connected to each retort by short 7 in. cast iron pipes, and the gases are then exhausted into a condenser, consisting of a mild steel shell with tube plates at the bottom and top, connected by a number of steel tubes, the cooling water passing upwards in opposite direction to the gases. The condensed tar and liquid overflow through a seal pot into an underground separator and receiver. The suction in the retorts, about 20 in. W.G., and through the whole of the installation, is obtained by means of "Bryan-Donkin" exhausters housed in a steel building at the end of the coal bunker stage, the equipment consisting of two exhausters, controlled by hydraulic regulators actuating the steam valves,

driven by direct coupled steam engines on a combined base plate, each exhauster being capable of handling 700,000 cubic feet of gas per 24 hours. The gases, after passing through the exhausters, are then treated in a "Pelouze and Andouin" tar extractor constructed by Messrs. W. C. Holmes and Co. Ltd., to remove the tar fog. This is divided horizontally into two compartments. The lower compartment is the gas inlet chamber, whilst in the upper is the drum arrangement which separates the tar particles and forms also the gas outlet chamber. The drum consists of a single horizontal malleable iron octagonal plate, containing underneath a framework supporting a series of removable vertical iron plates. There are 6 sets of these plates, each consisting of 6 plates, punched alternately with slots and holes. The composite drum has a tar seal at the lower end, and gives a wire drawing effect so that the heavier tar particles are separated from the gases. The drum is suspended over an inner cylinder by a chain, with counter weights attached, the height of the drum in the casing varying with the volume of the gas. In the exhauster house is also placed the tar and liquor pumps and wash-oil circulating pumps, all in duplicate.

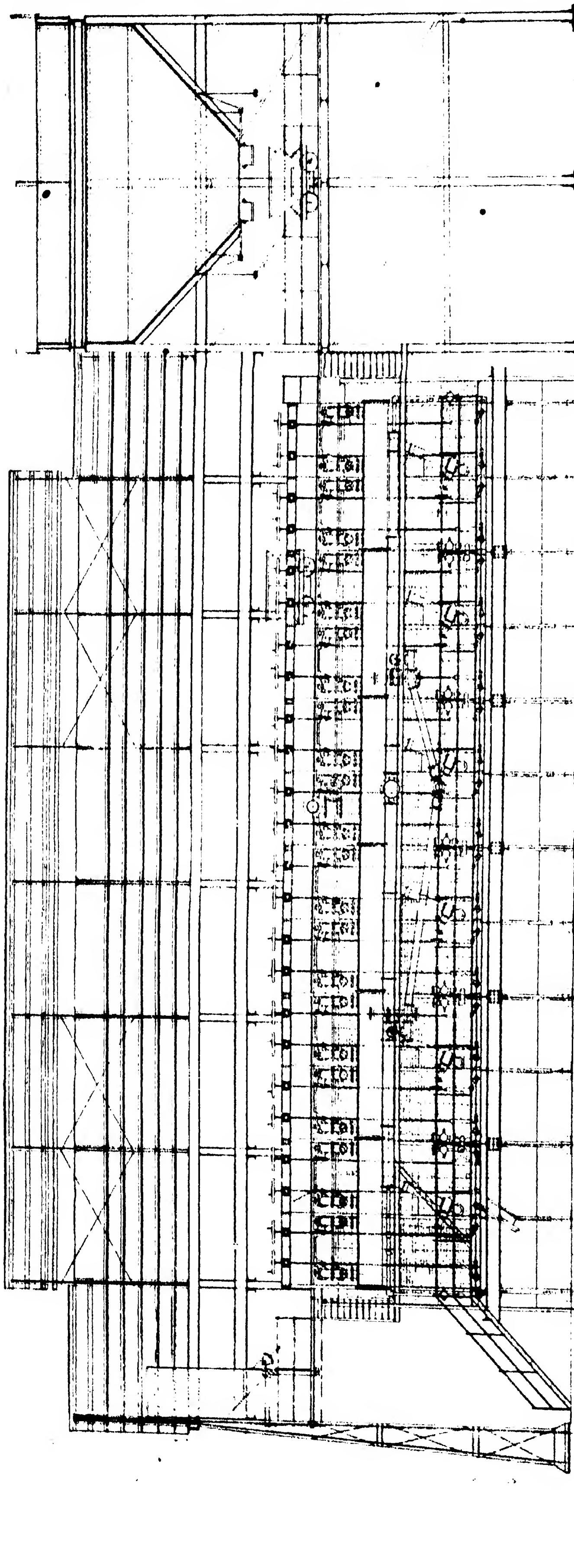
The gases then pass through two washers of the vertical centrifugal type, arranged in series, one washer removing the ammonia by means of a water spray, whilst the other, by means of a wash-oil spray, removes the light hydrocarbons for the production of motor spirit, both these washers being electrically driven. These washers, by Messrs. Kirkham, Hulett, & Chandler Ltd., consist of vertical cylindrical iron vessels, divided into a number of chambers. A vertical shaft, carrying sprays, passes through the centre of each chamber. These chambers consist essentially of specially designed trays, with perforated rims, as seen in the illustration. The shafts and trays revolve at a speed of 100-150 revs per minute, and the gas passes up the washers in the reverse way to the travel of the wash liquor in the ordinary.

As already stated, in this particular installation the residual low temperature fuel is completely gasified, and there are 7 producers, 10 feet in diameter, and 10 feet high, the plant being arranged for the recovery of ammonia. The gas passes through a mechanical washer, an ammonia absorber, and a combined saturator, and then a cooler, with centrifugal pumps for the circulating water. The sulphate house consists of the usual ammonia absorber, centrifugal dryers, storage bins for the sulphate, etc. The residual gas is then conveyed by a 42 in. main pipe to the gas burners, and also by a by-pass for heating the retorts. The 3 gas-fired boilers, with superheaters, are of the water-tube type, 180 lbs. pressure, with a normal evaporation of 17,000 lbs. water each per hour, and the electrical plant consists of two steam turbines, made by Messrs. Fraser & Chalmers Ltd., with direct coupled alternators, each having a normal output of 1,250 K.W. These turbines are arranged on the economical "pass-out" system, and the low pressure steam is used in the producer plant, to which also all the exhaust steam from the turbo blowers and other steam auxiliaries is connected. The output of the whole factory is 4,200 tons of carbide per annum.

The yield from 1 ton average coal (say 30 per cent. volatile matter), carbonised by the "Tozer" process is approximately as follows: –

- 4,400 cubic feet of gas (600 B.Th.U. per cubic foot).
- 3.9 gallons motor spirit (2.6 gallons stripped from the gas),
- 19 gallons oil (S.G. 1.060),
- 12 lbs. sulphate of ammonia, and
- 15 cwt. residual low temperature fuel.

Light Oil Recovery Plant showing Rotary Scrubbers



FRONT ELEVATION OF RETORT BENCH WITH HOUSE AND BUNKER

INDUSTRIAL INDIA

The amount of gas used to heat the retorts is equivalent to 8-9 per cent. of the coal carbonised.

The heating value of the gas is about 550-650 B.Th.U. per cubic foot, but when stripped for motor spirit, by being washed with the middle oils from the by-product plant, and about 2½ gallons of motor spirit per ton of coal extracted, the residual gas has a heating value of 400-550 B.Th.U. Any surplus gas can be used as usual for power, heating, or mixing with towns gas.

The yield of motor spirit depends to some extent on the temperature of carbonisation, and to get the maximum yield a temperature of about 1,000 deg. F. is the best, and certainly not over 1,200 deg.F. Dr. Dunstan has carried out an elaborate series of experiments with the "Tozer" plant, and shown that at about 1,400 deg.F., the highest temperature the cast iron retorts will stand, the paraffinoid character of low temperature oils changes to the distinctly benzenoid nature of high temperature oils.

The yield of 22 gallons of oil can be fractionated as follows :—

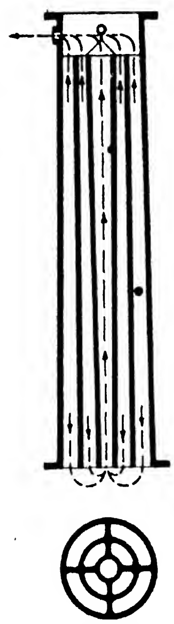
(1) Up to 338 deg. F. (170 deg. C.)—1.33 galls. 6.0% S.G. 0.800.

(2) Between 338-446 deg. F. (170-230 deg. C.).- 3.66 galls. 16.50% S.G. 0.970.

(3) Between 446-518 deg. F. (230-270 deg. C.) -1.99 galls. 9.0% S.G. 0.970.

(4) Between 518-662 deg. F. (270-350 deg. C.)-.-7.99 galls. 36.0% S.G. 1.04.

The fraction up to 338 deg.F. (170 deg.C.), 1.33 gallons, combined with the 2.61 gallons stripped from the gas, yielded 3.94 gallons of motor spirit of very fine quality, 0.780-0.800 being, when properly rectified, water white, and with an agreeable odour. The middle oils, 338-446 deg. F. (170-230 deg.C.), are good fuel and illuminating oils, and excellent for "Diesel" engines, having S.G. about 0.900 and flash point 138 deg.F. The heavy oils are good lubricants, and can be combined with the middle oils to give an excellent "Diesel" oil. These heavy oil fractions have a S.G. of 0.960, and a flash point 118-178 deg.F., which is within the Admiralty specification for fuel oils. The cressols in the oils vary from 10-22 per cent., and there is no trace of naphthalenes or anthracenes. There is also 5-8 per cent. of paraffin wax.



TOZER'S PATENT RETORT

The residual "Tozer" low temperature fuel contains 9-12 per cent. volatile matter, so that it is entirely free burning and very suitable for household purposes. The calorific value is generally about 7 per cent. less than the original coal, that is, good coal at 14,200 B.Th.U. gives a smokeless fuel of 13,300 B.Th.U., although in a few cases the calorific value is actually higher than the original coal. It burns, of course, smokelessly, and with a very high emission of radiant heat, being nearly double that of raw coal. It is also an exceptionally good fuel for conversion into producer gas, combined with ammonia recovery.

The 16 cwt. smokeless fuel gasified in a "Moore" by-product producer plant gives 124,000 cubic feet per ton, 145 B.Th.U. per cubic foot, corresponding to 90,200 cubic feet per ton of raw coal, and 106 lbs. of sulphate of ammonia, making a total per ton of coal of 121 lbs. ammonia. By this method of gasifying the residual fuel an enormous yield of ammonia can be obtained. The analysis of the producer gas is carbon monoxide 18.2 per cent., hydrogen 23.7 per cent., methane 1.4 per cent., carbon dioxide 12.1 per cent., and nitrogen 44.0 per cent.

In connection with the "Tozer" process, the following remarks made by Professor F. Mollwo Perkin, speaking in a discussion on a paper read by Mr. E. C. Evans, on Low Temperature Carbonisation, ("Journal of the Society of Chemical Industry," 31st July, 1918), will of be interest.

"The Tozer" retort, in which a vacuum was used, would deal with any class of coal, either coking or non-coking, and it was rarely there was trouble in getting the fuel out. It swelled up quickly and he thought that the action of the vacuum caused the heat to pass through the coal more rapidly, and it gave a really good fuel. With regard to the friability of smokeless fuel, he recently had a consignment from the "Tozer-Marshall" works, which had been three weeks on the railway in frosty weather, and it only contained about 10 per cent. of breeze, and even this was not wasted, because it could be easily briquetted."

It will not be without interest to give in conclusion the figures of a few typical coals carbonised by the "Tozer" process.

A sample of bituminous coal gave the following figures for a run of 25 tons. The analysis of the coal was :—

Water	2.08%
Volatile matter	31.83%
Fixed carbon	55.91%
Nitrogen	1.75%
Ash	8.43%

The yield was :—

Gas approx. 4,700 c. ft. (620 B.Th.U.)	
Motor spirit	2.25 galls.
Oil	16.42 galls.
Sulphate of ammonia ...	19.8 lb.
Low temperature fuel	15½ cwt.

The analysis of the residual low temperature fuel being :—

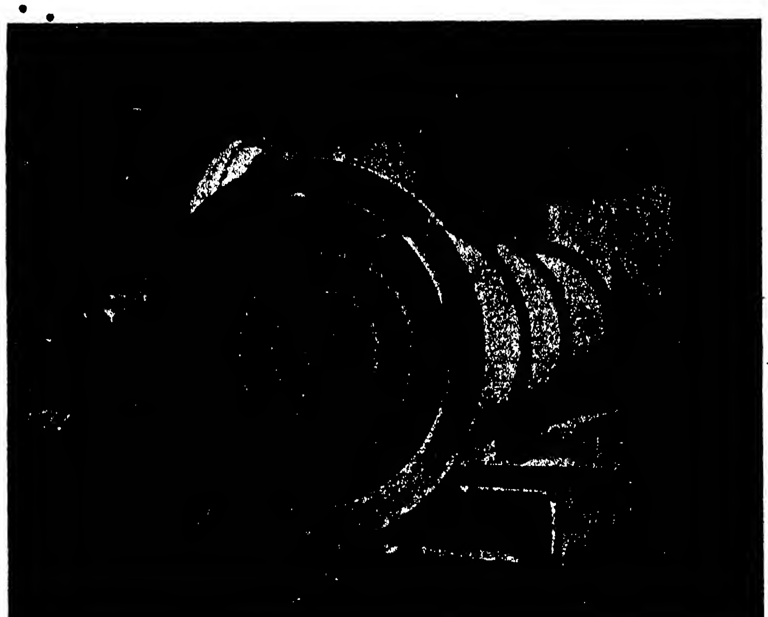
Volatile matter	10.34%
Fixed carbon	75.45%
Nitrogen	1.93%
Ash	12.26%

The crude oil was fractionated into :—

Motor spirit—
3.12 galls. (312 deg. F. 160 deg. C.)

Fuel and illuminating oil—
8.00 galls
(312-617 deg. F. 160 325 deg. C.)

Bituminous pitch ... ... 75.4 lb.



Tozer Retort

NAME OF COAL.	Analysis of Coal. Water.	Volatile Matter.	Fixed Carbon.	Ash.	Gas.	Yield per Ton of Coal. Motor Spirit Galls.	Light Oil Galls.	Heavy Oil Galls.	Total Oil. Galls.	Tar Acids. Galls.	Pitch. Cwt.	Sulphate of Ammonia. lbs.	Residual low temperature Fuel. Cwt.
1. Forest of Dean	3 10	31 20	58 57	7 00		2.00	5.40	5.40	15.20		...	13.0	15.9
2. Hulton Colliery	dry	34 73	50.06	7 21		0.83	4.90	7.90	18.40			20.7	14.7
3. Silkstone, winter slack	dry	32.85	58 31	8 84		0.40	4.40	10.50	19.80			12.1	15.5
4. Silkstone, 2 feet slack	dry	32 96	57 39	9.65		0.50	5.00	11.00	22.00			10.9	15.75
5. Niddrie cannel	dry	50 87	44.40	4 73		5.00	12.00	19.00			2.37	17.4	10.0
6. Newbattle cannel	1 44	50.23	44.06	4 33		5.00	13.50	28.50			2.06	21.8	10.0
7. Hucknall belt pickings	3 80	21 20	43 70	31.00		2 20	7.52	2.27	[illegible].20		0.39	11.0	14.4
8. Australian (Sulphide Corp.)	2 08	31 80	55.90	8 43		5 37		8.00	16.40		0.67	19.8	15.5
9. Wigan cannel	1.61	57.82	36.61	3 93		6.80	14.70	44 70	85.10	8.00	1.15	22.0	10.0

(See Table below for Analysis of residual low temperature tarless fuel).

The low temperature fuel on total gasification in a producer plant gave 145,000 cubic feet per ton (corresponding to 115,000 cubic feet per ton of raw coal), with a heating value of 147 B.Th.U. per cubic foot. The analysis of the gas was carbon monoxide 19.25 per cent., hydrogen 24.55 per cent., methane 1.10 per cent., carbon dioxide 12.25 per cent., and nitrogen 42.85 per cent. The nett yield therefore per ton of raw coal is, in addition to 115,000 cubic feet of gas, 5.37 gallons motor spirit, 8 gallons fuel and illuminating oil, 75.4 lbs. pitch, and 104 lbs. sulphate of ammonia.

The results obtained by carbonising 1 ton of various coals by the "Tozer" process are given above in the form of a table. In all cases 2.4 gallons motor spirit, to be obtained by stripping the gas, have to be added.

	Water.	Volatile matter.	Fixed carbon.	Ash.
1.	Dry	12 90	78 40	8.70
2.	Dry	8 26	82.85	8.89
3.	Dry	7.71	82 30	9.99
4	Dry	8 08	75.52	16.40
5				
6				
7.				
8.		10 30	75.40	18.26
9.	2 25	7.96	82.77	7.02

Analysis of residu l fuel

RECENT DEVELOPMENTS IN AERIAL WIRE ROPEWAYS

Mr. J. Walwyn White, in the course of a paper read at a recent meeting of the Liverpool Engineering Society, discussed the application of wire ropeways for transport purposes, and explained that there are two main types of ropeways. In one type only one rope is employed for the dual purpose of sustaining the weight of the load and of transporting it from one end of the line to the other. In the other, and more elaborate, type, three ropes are used. Two of these ropes are fixed, and stretch from one line of the section to the other, one end of each rope usually being anchored down, while the other end passes over a balance weight to keep the rope up to its work, and to compensate for the varying length of rope, owing to stretch and variations in the temperature. With regard to ropes, Mr. White pointed out that locked-coil ropes are nearly always used in modern installations by reason of the very low co-efficient of rolling friction on the smooth surface of the rope, this being in fact only five per cent. higher, other things being equal, than the co-efficient of friction of a railway wheel on a hard steel rail. It is, added Mr. White, no uncommon thing nowadays to see a locked-coil carrying rope, 2 in. in diameter, with a breaking strain of over 200 tons, giving a factor of safety of eight or ten on the working strain on the rope. One great advantage enjoyed by the double rope, or bi-cable system, continued Mr. White, is the ease with which angles, both vertical and horizontal, can be made absolutely automatically, and another is that the carriers, whether loaded or empty, are returned around the return terminal quite automatically. In addition, the grippers on modern installations are usually of the automatic gravity type, that is, the weight of the load itself gives the gripping power on the hauling rope, with automatic engagement and disengagement to and from this rope, so that, as matter of fact, the carriers are never touched by hand from the time they leave the loading rail, until they arrive back empty and are automatically detached from the hauling rope and run up to the buffer on the loading rail, where they are brought up and stand ready for their next load.

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS

Hydraulic Rams

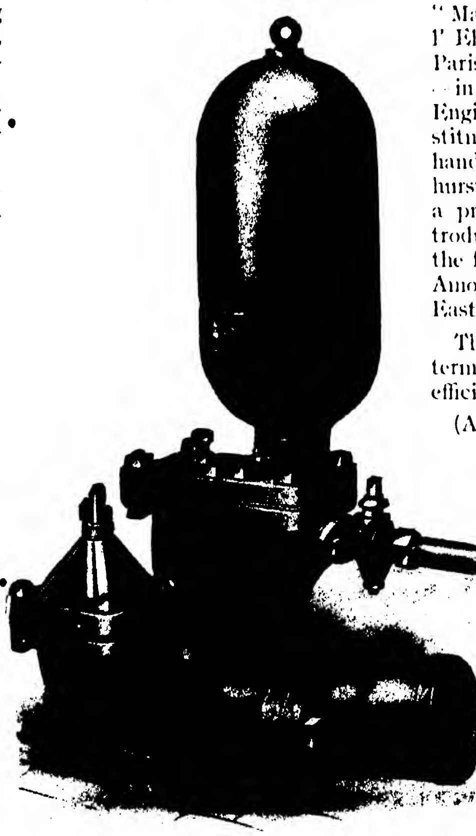
By E. W. ANDERSON, Assoc. M.Inst. C.E., M.I.Mech.E.

The following paper was read before the Midland Branch of The Institution of Mechanical Engineers, and gives the results of a very complete series of tests on the Hydraulic Ram: information which is not ordinarily available in works of reference.

THE hydraulic ram is a simple, ingenious, and useful machine for raising water where favourable conditions can be found for its installation. It is described in many text-books of engineering, but the information given is generally meagre. In this paper brief particulars are given concerning a long series of tests and experiments, made mainly by the author, extending over a period of several years. For the earlier experiments rams were used of the original type made by Messrs. Easton & Amos; but, as a result of the experience gained, a new design was adopted with which the later experiments were carried out, and with the results of which the paper mainly deals. It has been called the "Anderson" ram to distinguish it from the older pattern.

The principle of the hydraulic ram was explained by the author's father (the late Sir William Anderson, K.C.B., D.C.L., F.R.S., a Past-President of this Institution), in his "Chatham" lectures on Hydraulic Machinery as follows:—"When a current of water is flowing down a pipe so as to fill it completely, and its course is suddenly arrested, the energy stored in the water expends itself partly in stretching the material of the pipe, partly in compressing the water, and partly in compressing the air contained in the water. All three substances are highly elastic and consequently, when strained suddenly, recoil and tend to cause the water to rebound just like one elastic solid rebounds from impact with another." The water is thus for a short time under considerable pressure; so that, if a small hole is made in the pipe at, or near the bottom, it will squirt out with great force till the above described reaction takes place.

The first idea of utilizing the principle upon which the action of this machine is based occurred to one Whitehurst, a clockmaker of Derby, in the year 1772; and he is said to have made and fixed an apparatus to supply water to a brewery in Oulton, Cheshire. A description of the Whitehurst apparatus, which was not automatic, will be found in Morin's "Machines et Appareils destines a l' Elevation des Eaux," published in Paris in 1863. Twenty-six years later in 1798 the celebrated French Engineer, Montgolfier, by the substitution of an automatic valve for the hand-cock required with the Whitehurst device, converted the latter into a practical machine, which was introduced to England by James Easton, the founder of the firm of Easton & Amos, which subsequently became Easton & Anderson.



External View of Anderson Ram. *Easton, Courtney & Derbyshire*

There are two ways (which may be termed A and B) of calculating the efficiency of a ram:

(A) Suppose H to be the height from which the water falls to the ram, and H' the height above the supply water level of the point to which it is delivered plus any allowance for friction, then the height of the delivery point above the ram will be H + H'. Similarly if Q be the quantity of water which flows away from the outer valve, and Q' the quantity delivered, then the quantity supplied to the ram will be Q + Q'. In the experiments the efficiency was calculated by this formula.

$$\text{Efficiency per cent.} = \frac{Q' \, (H + H')}{(Q + Q') \, H} \times 100$$

TABLE I.

4" "ANDERSON" RAM, ABOUT 13' FALL, PIPE 72' LONG, WORKING AT LOW RATIOS OF LIFT TO FALL.

Stroke of Outer Valve.	Water delivered, galls. per min.	Ratio of Lift to Fall.	No of Beats per min.	Efficiency.	Remarks.
[illegible]"	14.40	2.08	49	67.5%	Spring on Outer Valve.
[illegible]"	10.46	2.86	58	69.5%	Ditto.
[illegible]"	8.37	3.80	60	70.8%	Ditto.
[illegible]"	6.20	5.50	66	77.7%	No Spring on Valve.
[illegible]"	13.43	2.88	56	84.0%	Spring on Outer Valve.
[illegible]"	9.80	3.79	62	80.0%	Ditto.
[illegible]"	7.66	4.74	62	85.6%	Ditto.
[illegible]"	6.31	5.70	64	83.5%	No Spring on Valve.
[illegible]"	12.85	1.87	62	75.6%	Spring on Outer Valve.
[illegible]"	8.37	2.80	76	78.4%	Ditto.
[illegible]"	6.52	3.75	81	77.1%	Ditto.
[illegible]"	4.05	5.57	88	82.1%	No Spring on Valve.

TABLE II.

COMPARATIVE EFFICIENCIES OF RAMS WITH BALL AND MUSHROOM INNER VALVES.

Stroke of Outer Valve.	Ratio of Lift to fall.	Ball Valve. Weight 13¼ oz.	Mushroom Valve, [illegible]" Stroke.	
			Weight 11 oz.	Weight 4¼ oz.
[illegible]"	4	70.9%	73.6%	75.3%
[illegible]"	6	66.5%	68.9%	68.9%
[illegible]"	8	62.7%	62.8%	60.4%
[illegible]"	4	65.5%	69.8%	71.9%
[illegible]"	6	66.0%	69.0%	67.4%
[illegible]"	8	61.1%	63.6%	61.9%
[illegible]"	10	53.0%	59.9%	58.4%

TABLE VI.

EFFICIENCIES OF 1¼" "OWENS" RAM WITH VARYING LENGTHS OF FALL PIPE AND RATIOS OF LIFT TO FALL.

Fall 11 feet in all, but 1 in 28 when it was 6 ft. 6 in. Stroke of Outer Valve [illegible]".

Ratio of Lift to Fall.	Vertical.	Proportion of Fall to Length of Fall Pipe.					
		1 to 2.	1 to 4.	1 to 8.	1 to 12.	1 to 14	1 to 28.
4	64.0	56.6	78.6	81.3	84.5	79.5	78.6
6	13.0	44.0	70.5	70.7	81.7	79.1	79.5
8	—	—	61.3	66.6	73.4	74.7	86.7
10	—	—	41.7	39.0	69.5	—	78.3
12	—	—	—	34.5	70.2	68.2	75.0
14	—	—	—	—	47.7	44.3	66.9
16	—	—	—	—	23.6	27.6	51.6
18	—	—	—	—	—	25.3	50.0
20	—	—	—	—	—	15.2	49.5
22	—	—	—	—	—	—	27.9
24	—	—	—	—	—	—	27.8

The quantity $Q + Q^1$ is, of course, obtained when the supply entering the fall pipe is measured.

(B) This method employs the formula :—

$$\text{Efficiency per cent.} \quad \frac{Q^1 \times H^1}{Q \times H} \times 100$$

Here the quantity Q is given at once if the water flowing from the valve is measured, and not the total supply, but it can, of course, be obtained from the total supply by deducting the quantity delivered. An example may be given of the two methods which shows that the results differ somewhat. A 4 in. "Anderson" ram used a total of 39.51 gallons per minute, and delivered 1,323 gallons per minute to a height of 258 feet, the fall being 13 feet.

Efficiency per cent. by A=66.4 and by B=65.2. When the efficiency is calculated by method A, the ratio of height to which water is delivered plus friction (which will in future be called "lift") to the fall is :

$$\frac{H + H^1}{H},$$

and by method :

$$B—\frac{H^1}{H};$$

therefore the latter figure is always one less than the former. Thus in comparing the efficiencies by the two methods, the ratio R of method A should be compared with the ratio R—1 of method B.

The main components of a hydraulic ram are :—

The outer or automatic valve.
The inner or delivery valve.
The air-vessel.
The snift or air-valve.
The main casting or body.
The fall pipe.

The Outer Valve.—Experiments were made, keeping other conditions as constant as possible, with a fall pipe 73 feet long, and height of fall 23 feet, against delivery heads, having the ratios of 4, 6, 8, and 10 times the fall. Though there were discrepancies, the general results justified the following conclusions :—

(1) The lighter the valve the higher the efficiency, especially with the longer strokes of the valve, namely : ⅜ in., ½ in., ¾ in., and 1 in.

(2) The lighter the valve the less water is delivered. Exceptions to this were found with the longer strokes of the valve against ratios of heads of 8 and 10 to 1.

TABLE III.

4" "ANDERSON" RAM, ABOUT 13' FALL, PIPE 72' LONG. EFFICIENCIES WITH INCREASING RATIOS OF LIFT TO FALL AND GRADUATED STROKE OF INNER VALVE.

Stroke of Outer Valve.	Stroke of Inner Valve.	Total water used. Gallons per minute.	Water delivered. Gallons per minute.	Ratio of Lift to Fall.	Number of Beats per minute.	Efficiency.	Average Efficiency.
5/8"	0.50"	44.72	9.57	3.89	64	83.2%	84.1%
5/8"	0.50"	44.97	9.57	4.00	64	85.1%	
5/8"	0.30"	43.89	6.20	6.00	66	84.7%	84.0%
5/8"	0.30"	45.45	6.38	5.94	67	83.1%	
5/8"	0.25"	43.13	4.50	7.98	68	83.2%	86.0%
5/8"	0.25"	40.64	4.44	8.12	66	88.7%	
5/8"	0.15"	40.53	3.38	9.93	69	82.7%	82.6%
5/8"	0.15"	40.29	3.31	10.04	68	82.6%	
5/8"	0.10"	36.35	2.46	11.88	65	80.4%	79.0%
5/8"	0.10"	36.30	2.34	12.05	65	77.6%	
5/8"	0.10"	35.90	1.82	14.03	66	71.0%	70.6%
5/8"	0.10"	36.30	1.82	14.02	66	70.3%	
5/8"	0.075"	41.33	1.73	16.10	70	67.4%	66.8%
5/8"	0.075"	41.29	1.69	16.13	71	66.2%	
5/8"	0.05"	42.73	1.59	18.07	72	67.5%	67.0%
5/8"	0.05"	42.50	1.56	18.10	72	66.5%	
5/8"	0.05"	39.70	1.309	19.90	69	65.6%	66.0%
5/8"	0.05"	30.51	1.323	19.84	70	66.4%	

Note.—In the first three experiments the outer valve was fitted with a spring, to assist in opening it at the low ratios of lift to fall.

4" ram : 20 feet fall, 364 feet lift, 18.2 to 1 ratio. Efficiency 71.4 per cent, and with shorter stroke of outer valve 67.7 per cent.

4" ram : 12.4 feet fall, 142 feet lift, 11.5 to 1 ratio. Efficiency from 72 to 81 per cent., with different strokes of outer valve.

1½" ram : 11 feet fall, 70 feet lift, 6.3 to 1 ratio. Efficiency 76.4 per cent.

2" ram : 5.5 feet fall.

100 feet lift,	ratio 18 to 1.	Efficiency 53	per cent.
140 ,,	,, 25 to 1.	,, 50.6	,,
180 ,,	,, 33 to 1.	,, 48.7	,,
230 ,,	,, 41 to 1.	,, 53.0	,,
320 ,,	,, 58 to 1.	,, 23.4	,,

be insufficient remaining to bring about the automatic action of the valve, and therefore the ram will cease working. This is also demonstrated by the fact that when starting a ram to work with the delivery pipe empty so that there is but little resistance to the flow of water into the air vessel, it is necessary to operate the outer valve by hand several times, until the air-vessel and pipe are charged sufficiently to give the required resistance to enable the valve to work automatically. It is, however, possible to make a ram work at a lower ratio of lift to fall, even down to below 2 to 1, by the device of putting a spring on the outer valve tending to open it. Table I. gives the figures obtained from tests on a 4 in. Anderson ram. The reason the efficiency of the middle series is so much better than the others, is that the area through the inner valve was greater. This will be dealt with later on when considering the inner valve. In the last set the outer valve had a shorter stroke, and this explains the better efficiency compared to the first set, as the area of the inner valve was the same in both.

The result of many experiments upon the effect of varying the stroke of the outer valve within reasonable limits, has been to formulate the general rule that increasing the stroke increases the quantity of water delivered, but reduces the efficiency,

TABLE IV.

EFFICIENCIES OF 4" "ANDERSON" RAM COMPARED WITH THOSE GIVEN BY VARIOUS TABLES AND FORMULÆ.

Ratio of lift to fall	4	6	8	10	12	14	16	18	20	
Anderson 4" Ram	84.1	84.0	86.0	82.6	79.0	70.6	66.8	67.0	66.0	No ratio at which efficiency is zero has yet been reached.
Table given in 1877 by C. L. Hett	—	79	68	56	49	41	34	27	20	Efficiency falls to zero at 27 to 1.
Table in "Molesworth's Pocket Book," 1918		72	62	50	43	35	28	20	15	Efficiency falls to zero at 26 to 1.
Some Efficiencies from "Kempe's Year Book"	85 (3.9)	75 (6.38)	67 (7.65)	-	35 (12)	-		—	18 (19.6)	Figures in brackets are the actual ratios.
From "Mark's Handbook," American	72	61	52	—	37		25	—	14	Efficiency falls to zero at 26 to 1.
Formula—"Molesworth's Pocket Book," 1918. Efficiency $= 1.12 - 0.2\sqrt{H \div h}$	77	67	59	52	46	40	35	30	25	Efficiency falls to zero about 31 to 1.
Daubisson's Formula from "Molesworth." Efficiency $= 1.42 - 0.28\sqrt{H \div h}$	94	89	68	58	49	41	34	27	20	Efficiency falls to zero about 26 to 1.

(3) The lighter the valve the higher is the number of beats per minute. There were some exceptions to this with the shorter strokes of ⅛ in. and ¼ in.

It was found, as might be expected, that there is a minimum ratio of lift to fall at which an ordinary ram will not work, and it is usually somewhere about 4 to 1.

It is easy to understand that, if the energy can dissipate itself freely by driving water into the air-vessel against a small resistance, there may

and vice versa, as shown in the first and third sections of Table I, though there have been, as usual, exceptions to this. The rule adopted for fixing the best normal stroke of the valve for practical purposes, was to make it that in which the area through the

TABLE V.

SHOWING THE WORKING OF "ANDERSON" RAMS. GALLONS DELIVERED PER MINUTE.

Proportion of lift to fall.		½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	%
	Gallons used		5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	80
4	Size of Ram		1½	1½	2	2	2	3	3	3	3	3	4	4	4	
	Do. do	3.20	6.41	9.61	12.82	16.02	19.23	22.43	25.64	28.84	32.05	35.25	38.46	41.66	44.87	
5	Do. do.	1½	1½	2	2	3	3	3	3	3	4	4	4	4	4	78
	Do. do.	4	8	12	16	20	24	28	32	36	40	44				
6	Do. do	1½	1½	2	2	3	3	3	4	4	4	4				75
	Do do.	4.72	9.46	14.18	18.92	23.64	28.38	33.10	37.84	42.56						
7	Do. do.	1½	2	2	3	3	3	4	4	4						74
	Do. do.	5.54	11.11	16.65	22.22	27.76	33.33	38.87								
8	Do. do.	1½	2	3	3	3	4	4								72
	Do. do	6.34	12.67	19.01	25.34	31.68	38.01									
9	Do. do.	1½	2	3	3	4	4									71
	Do. do.	7.24	14.50	21.74	29.00	36.24	43.5									
10	Do. do.	1½	2	3	4	4	4									69
	Do. do.	8.20	16.42	24.62	32.84	41.04										
11	Do. do	1½	3	3	4	4										67
	Do. do	9.22	18.46	27.68	36.92											
12	Do do	2	3	4	4											65
	Do. do	10.32	20.63	30.95	41.26											
13	Do. do	2	3	4	4											63
	Do. do.	11.48	23.00	34.48												
14	Do. do.	2	3	4												61
	Do do.	12.70	25.40	37.11												
15	Do. do.	2	3	4												59
	Do. do.	13.80	27.60													
16	Do do	2	4													58
	Do. do.	15.20	30.30													
17	Do do	2	4													56
	Do do	16.66	33.30													
18	Do. do.	3	4													54
	Do do.	18.26	36.50													
19	Do. do.	3	4													52
	Do do	29														
20	Do. do.	3														50

Efficiencies upon which Table is based.

N.B. This Table is made upon the assumption that the actual height of fall does not affect the output of the Ram, or the efficiency, only the proportion that it bears to the height of lift, plus the friction of the delivery pipe.

The length of the fall pipe may, under ordinary circumstances, be made equal to from 6 to 10 times the height of fall.

TABLE VII.

RAM FOR RAISING CLEAN WATER BY USING DIRTY WATER 2" FALL PIPE 30' LONG, 13' 6" FALL.

Stroke of Outer Valve.	Depth of Suction.	Ratio of Lift to Fall.	Number of Beats per minute.	Water used gallons per minute.	Water raised gallons per minute.	Efficiency. Per cent.
[illegible]	72½"	4	136	9.23	1.10	47.0
[illegible]	68¼"	5	132	9.23	0.93	50.0
[illegible]	67¼"	6	136	9.52	0.90	56.7
[illegible]	66¼"	7	138	9.52	0.63	46.0
[illegible]	63"	8	132	8.82	0.62	56.0
[illegible]	68½"	9	134	9.23	0.46	44.0
[illegible]	67¼"	10	136	8.70	0.41	47.0
[illegible]	63"	11	126	7.80	0.27	38.0
[illegible]	63"	12	126	7.90	0.23	35.0
[illegible]	63"	13	124	7.14	0.20	36.0
½"	66"	9.14	96	14.00	0.86	56.0

outer valve was equal to the area of the fall pipe. Then, by lengthening the stroke within reasonable limits, a larger delivery of water could be obtained, but with the sacrifice of efficiency, which in many cases would not matter, and by shortening it the delivery would be reduced, but the efficiency improved. If, therefore, a ram was required to give the largest possible delivery with a limited supply of water, it would be an advantage to put in a large ram and give it a short stroke; or if there was abundance of water, a small one with a long stroke might answer the purpose and would be cheaper.

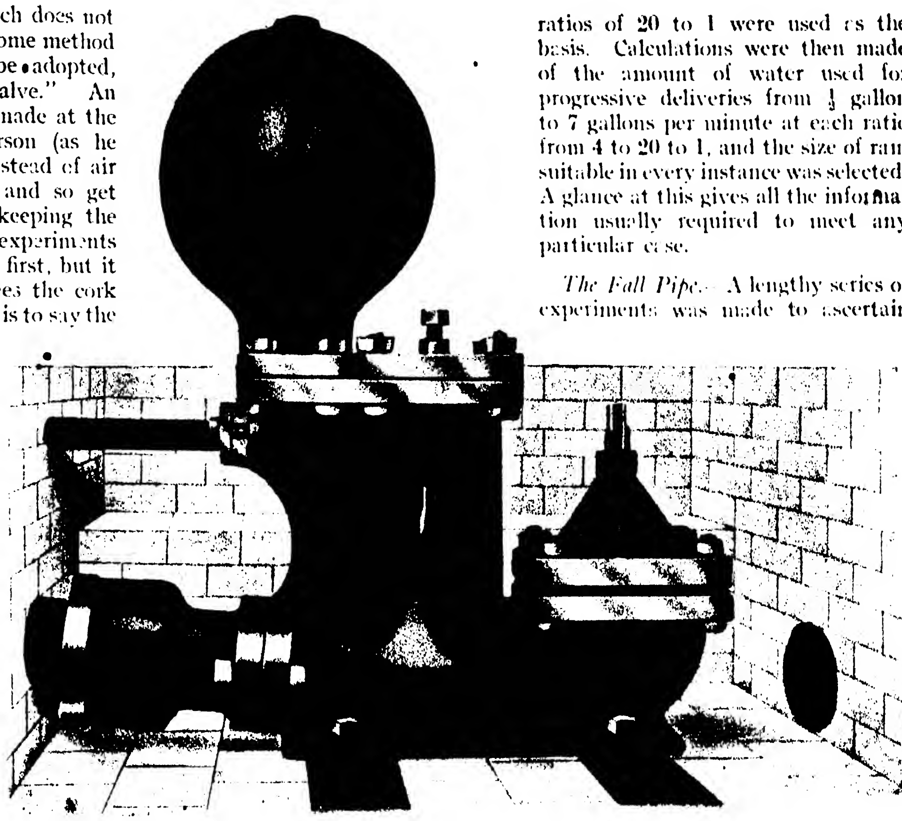
The Inner Valve.—The results of tests to determine the relative efficiencies of ball and mushroom inner valves are given in Table II. It will be seen that, with one exception, the mushroom-valve gave the better result, and the weight of it did not seem to be of great importance. The lighter valve appeared to suit the lowest ratio best, and the heavier the higher ones. With regard to the stroke and area of the inner valve, it has been found good practice to allow one square inch of area through the valve for every gallon of water to be delivered per minute. Table III. gives the results of tests with a graduated stroke of inner valve, maintaining the aforesaid rule as to area.

The Air Vessel.—In practice, a ram will not work without an air vessel. It is easy to appreciate that the water in a long delivery pipe cannot be stopped and started say at from 20 to 200 times a minute, and that it must be kept flowing steadily at a uniform rate; a condition which depends entirely upon the satisfactory functioning of the air-vessel.

A most important point is, of course, to keep it properly charged with air. Certain waters in passing through the ram are found to give off air in sufficient quantity to keep the vessel charged. Where, however,

water has to be used which does not possess such a property, some method of supplying air must be adopted, such as the "Snift valve." An interesting attempt was made at the suggestion of Dr. Anderson (as he then was), to use cork instead of air for the elasitc medium, and so get rid of the difficulty of keeping the air vessel charged. The experiments gave promising results at first, but it was found that by degrees the cork became water-logged, that is to say the cells became gradually permeated by and at last filled up with water, so that it ceased to act as required and the idea had to be given up.

The Snift Valve.—The function of this valve is to keep the air-vessel supplied with air. It is a small valve opening inwards into the body of the ram usually just below the inner valve. When the reaction takes place and a slight vacuum is momentarily formed in the body, a whiff of air is drawn in through the snift-valve, and finds its way at the next beat of the ram into the air-vessel, the snift-valve, of course, closing again under the pressure.



Latest Improved Pattern. *Easton, Courtney & Darbyshire.*

The Body.—The great object to be attained is rapid closing of the valve, and anything which tends to retard this will cause loss of efficiency. In a badly shaped body there may easily be eddies in the water which will have such an effect. The author's experiments have shown that the area of the annulus between the edge of the valve and the body should be made rather less than that through the valve itself, so that the water should have a higher speed locally, and thus tend to close the valve rapidly. Table IV. gives the efficiencies obtained from various published Tables and formulae which may be taken fairly to represent general practice, set out in parallel lines with those of the 4 in. Anderson ram.

Some of the Tables and formulae do not make it clear upon which method of calculating the efficiency they are based. In such it has been assumed that the B method has been used, and the comparison has been made by using the ratio=R—1. For example, taking the ratio 8 as given in the top line of Table IV., the efficiency in the third line is 68 per cent., which in Hett's Table is that for a ratio of 7 to 1.

His efficiency for 8 to 1 is 63 per cent., so that the higher figure has been used for comparison which is on the safe side. The experiments with the Anderson ram were not continued beyond a ratio of 20 to 1, because the fall being about 13 feet, the delivery head would be about 260 feet, and it was not thought wise to go higher; but with a lower fall, 4.75 feet, a 4 in. ram in actual use was tested with a throttled cock and pressure gauge up to a ratio of 46.3 to 1, when the efficiency was 44.3 per cent.

Particulars have also been kindly supplied by Mr. J. R. Easton, a grandson of the original introducer of the Montgolfer Hydraulic Ram into this country, of some tests made upon Anderson rams in actual work as shown in Table V.

These figures indicate that, so far, the point of zero efficiency has not been reached with the Anderson ram. For practical use relating to such rams, Table V. has been prepared in which the efficiencies assumed and considered safely obtainable up to ratios of 20 to 1 were used as the basis. Calculations were then made of the amount of water used for progressive deliveries from ½ gallon to 7 gallons per minute at each ratio from 4 to 20 to 1, and the size of ram suitable in every instance was selected. A glance at this gives all the information usually required to meet any particular case.

The Fall Pipe.—A lengthy series of experiments was made to ascertain the best proportion of the length of the fall pipe to the height of fall available. Table VI. gives the efficiencies obtained. The inferences to be drawn from this Table are, that the longer the pipe in relation to the fall, the better for both efficiency and capability of functioning of the ram under all ratios of lift to fall up to 24 to 1, and that the shorter the pipe, the smaller the ratio above 4 to 1, at which it will work. Varying the stroke of the outer valve somewhat altered these conclusions. In general, it may be said that the best results are obtainable with fall pipes having a length of from six to ten times the fall.

Dirty Water Ram.—In this type, water from one source of supply may be pumped by using water under a small head from another source. Its name arises from the fact that its usual duty is to pump clear water from a well or spring, by means of dirty or contaminated water from some other source, such as a river. Table VII. gives the results of tests, which are a good deal lower than those of the ordinary Anderson ram. It will be observed that the fall pipe was very short compared with the fall.

The Influence of Structure on the Combustibility and other Properties of Solid Fuel

(*All blocks used in this article are loaned by courtesy of the Society of Chemical Industry*).

*At a recent meeting of the Society of Chemical Industry, a paper was read on the above subject by E. R. Sutcliffe, Wh. Ex., A.M.I.M.E., and Edgar C. Evans, B.Sc., F.I.C., M.I.M.E., from which we have taken the following extracts. This extremely interesting and instructive paper gives the results of a vast amount of research and experimental work, and reveals the importance of taking into account the physical structure of solid fuel, a feature of the fuel problem on which we have little knowledge**

THE constitution of coal has been studied by a number of observers, and notably by Wheeler and his collaborators, and the essential difference between various coals can easily be realised by a study of photomicrographs of coal sections. But whilst these photographs show clearly the internal structure of coal, whilst they show the heterogeneous character of most coals, and explain the difference in ignition temperatures of various coals, they do not of themselves explain the very considerable differences in combustibility. Some coals are said to be "bright" and "active" in combustion, others again of similar content of volatile matter are said by stokers to be "dead" in burning. The reason for this is not entirely due to composition or constitution; it is a matter in which the structure of the carbonaceous residue left after the volatile products have been burnt off, plays an extremely important part.

In studying on a large scale the factors that play a part in determining the combustibility of a fuel, the first step is to obtain a homogeneous product. At the outset it will be noticed that homogeneity itself, apart from other factors, exerts an important influence.

Homogeneity of size.—The first attempt to obtain a homogeneous fuel commercially have been made in the direction of sizing the coal. Sizing non-caking steam coals, anthracite coals, and some American high-volatile coals (*e.g.* Illinois coals), has proved of considerable advantage for steam raising purposes.

In the case of non-caking bituminous coals, the following advantages are claimed for sizing (Malcolmson, 1st Annual Convention Int. Railway Fuel Assoc., 1909): (1) Increase of fuel and boiler efficiency. (2) Less loss of fuel in ash. (3) Less smoke. (4) Uniform combustion ensuring greater capacity of furnace. (5) Less draught needed. (6) Longer life of grate. (7) Furnace under better control, steam can be raised more rapidly. (8) Less danger of spontaneous combustion of stored coal.

Influence of dimensions of fuel particles.—*Ceteris paribus* the smaller the particles of coal, the greater the combustibility. This, of course, arises from the fact that the surface area increases considerably in proportion to the bulk as the diameter decreases. This principle is applied in using anthracite for raising steam. Anthracite is by no means a fuel of high combustibility, and is extremely difficult to burn in an ordinary boiler furnace in large sizes. Yet anthracite peas carefully sized make an ideal boiler fuel, and have better steam-raising qualities than even high-class Welsh steam coals.

Fig. 1. Low Temperature Coke, No. 2 Rhondda Coal

The ultimate possibilities in this direction are obtained in the case of powdered fuel. The extremely high degree of combustibility of coal dust in a fine state of subdivision has long been realised in connexion with the study of mine explosions, and the same principles which make coal dust such an explosive agent, are now made use of commercially in many applications of powdered fuel.

Powdered fuel, however, is by no means an ideal material. It cannot be stored, it cannot be transported *per se*, and is liable to spontaneous combustion. For this reason attempts have been made, as in the colloidal fuel process, to make it transportable in the form of an emulsion of oil and coal. There is, however, a method of retaining to some extent the highly combustible extremely active properties of powdered fuel, and at the same time make it easily transportable, and that is to briquette it.

The advantages of fine grinding prior to briquetting have long been known to the briquetting industry. It increases the combustibility of the briquettes, and improves their appearance, but on the other hand finely ground coals require a greater percentage of binder than coarsely ground material, and as a rule, if made by the ordinary process with pitch as a binder, the briquettes are rather weaker. In practice, therefore, a compromise is effected, and the coal is only ground to the extent that would be effected by an ordinary Carr's disintegrator. Even so, briquettes made with pitch possess many advantages over coal, and these

* *NOTE.—The full paper is published in the journal of the Society, Issue No. Vol. xli, No 12, pp 196T to 208T.*

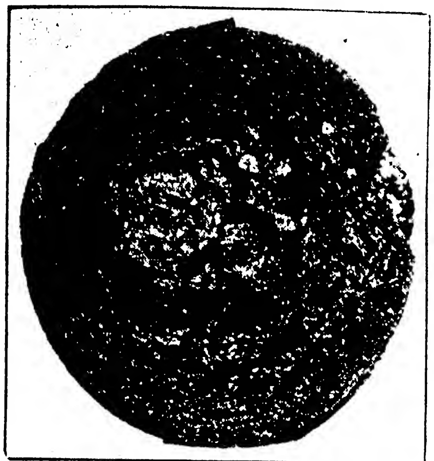


Fig. 2. Low Temperature Coke, No. 2 Rhondda Coal mixed with a proportion of Coke Breeze

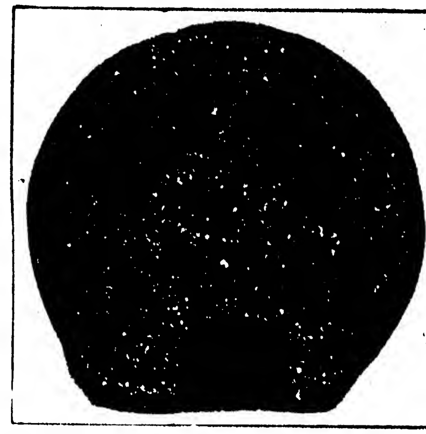


Fig 3. Low Temperature Coke, No. 2 Rhondda Coal mixed with a proportion of Preheated Coal

have been surmised as follows (vide Malcolmson, "Commercial aspects of the Coal Briquetting Industry," Trans. 8th Int. Cong. Appl. Chem., Vol. 25). (1) Briquettes can be readily transported and handled and stored for an indefinite period without deterioration. (2) Briquettes when burnt in locomotives under standard conditions show an increased boiler efficiency over coal of the same calorific value amounting to 15 per cent. in favour of the briquettes. (3) It has been demonstrated that 25 per cent. more briquettes than coal can be burnt per sq. ft. of grate area per hour.

In other words, briquettes are more combustible than raw coal, a result entirely due to the difference in structure between briquettes and coal.

The fact that the briquettes are more combustible than the raw coal is brought out by a series of comparative boiler trials made at the South Wales School of Mines on raw coal, briquetttes made from the same coal with pitch as a binder, and briquettes from the same coal made without a binder. In a series of preliminary laboratory tests it was noticed that briquettes made without a binder when burnt in a bomb calorimeter burnt with a rapidity far greater than that of either raw coal, or of briquettes made with pitch, the period of combustion being very often 30 per cent. less than that of coal. This increased combustibility is shown with still greater clearness in the series of tests carried out at the South Wales School of Mines.

These tests are imperfect in several respects; the boiler efficiency was low (as would naturally be expected in the case of a hand-fired experimental boiler installation), and in many respects they failed to bring out to the best advantage the superiority of the briquetted fuels. Still the following points may be noticed:—

(1) The heat transmitted per square foot of heating surface per hour was 4,070, 4,039, and 4,650 B.Th.U. respectively.

(2) The weights of dried fuel burnt per square foot of grate area

Fig. 9. Gas Coke

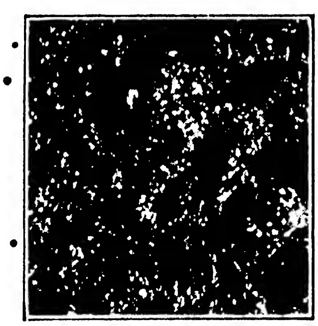


Fig. 10. Vertical-Retort Gas Coke

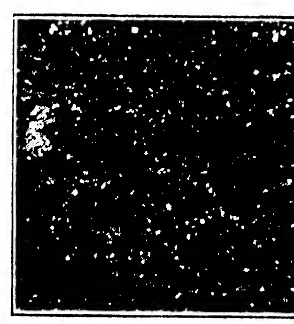


Fig. 11. Blast-Furnace Coke

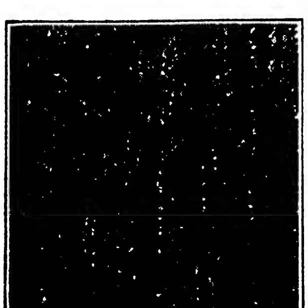


Fig. 12. Bulk Charcoal along the Grain

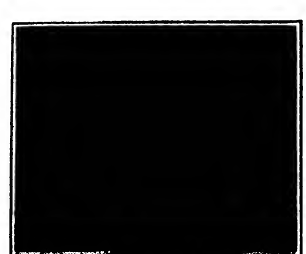


Fig. 7. Pure Coal Briquette, Carbonised (Lancashire Coal mixed with 25% Coke Breeze)

Fig. 13. Bulk Charcoal across the Grain

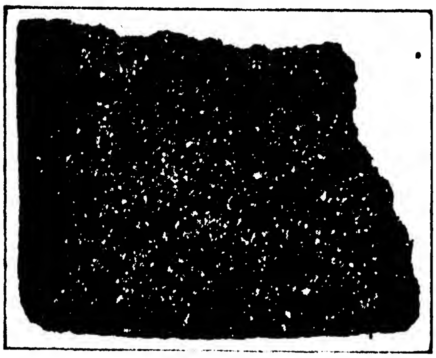


Fig. 5. South Metropolitan Smokeless Fuel

per hour were 13·78, 15·05, and 16·4 lb. respectively.

(3) The equivalent evaporations per lb. of carbon value from and at 212 deg. F. were 7·31, 7·31, and 7·35 lb. respectively.

(4) A constant draught of 0.6 in. was maintained in each case, and a uniform rate of feeding the coal was adopted in each case. The briquettes made without a binder, however, burnt away so quickly, that with the thin fires maintained, it was found very difficult to keep the grate fully covered at the end of the charging period. The efficiency was therefore reduced, and a better result could have been obtained either by reducing the draught or by working the boiler at a higher capacity.

The results, however, are sufficient to show that the combustibility of briquetted fuel increased with the degree of fineness of the coal, and with the homogeneity of the product.

Factors influencing the combustibility of carbonised fuels.—A very brief study of carbonised fuels is sufficient to show that the factors which determine their combustibility are more numerous and complex in character than is generally realised. The character of the fuel carbonised, temperature of carbonisation, the rate of carbonisation, and even the pressure under which the heat is effected, all play a part in determining the character and the combustibility of the resulting carbonised fuel.

The following experiment illustrates in an interesting manner the effect of a prolonged carbonising period. A finely ground coking coal was briquetted without a binder, and the briquettes passed through an internally heated retort. Heating took place so slowly that a period of 72 hours was taken in bringing the charge to its maximum temperature of 1,000 deg. C. The briquettes retained their shape, but contracted during the process until the coke had a sp. gr. of 1.2, its structure consisting of a large number of minute cells with thin walls. The combustibility of this fuel was of the same order as that of charcoal. When once thoroughly ignited a lump of this fuel could be removed from the fire, and if protected from draughts would continue to burn for several hours. In one test made a piece of a size 3 in. × 2 in. × 1½ in. made red hot and placed on a fireclay slab away from the fire, burnt for over six hours, until all that remained was a small piece 1 in. × ½ in. × ½ in.

Influence of preliminary treatment of coal.—A very prolonged carbonising period, is, of course, not easy to reconcile with economic requirements on a commercial scale, but several methods are available which allow of the ready escape of the volatile matter. It can be done by (1) blending coal with coke breeze (Fig. 2), (2) blending caking with non-caking coals, or (3) preheating a portion of the coal to eliminate the resinous matter and mixing the resulting material in the correct proportions with raw coal.

In order primarily to meet the economic requirements in large-scale production of smokeless fuel, the authors have developed a method of preliminary briquetting of coal without a binder, and subsequent carbonisation of the briquettes. In the case of most British coals swelling of the briquettes during carbonisation can be prevented by the addition of 20 to 30 per cent. of previously carbonised material to the coal, but in the case of a few coals containing a high proportion of resinous material it has sometimes been found necessary to adopt one or other of the alternative methods already mentioned.

Influence of structure.—A study of these carbonised briquettes throws a considerable light on the influence of structure on the combustibility of carbonised fuels. Research on this matter is still proceeding, and up to the present time it has not been found possible to make definite determinations of the relative combustibility of the various types of fuels that can be obtained by these processes. Sufficient has been done, however, to enable some of the principal factors involved to be determined, and these can be briefly outlined as follows :-

(1) *Influence of area of surface.*—The area of surface presented to the oxidising gases is, of course, an important factor. Combustion can only be maintained if the area of incandescent surface exposed to the air is sufficient to maintain the temperature of a sufficient mass of the fuel above the point of ignition. The area of surface of blast-furnace coke, for example, is much greater than that of anthracite, and the combustibility of the coke is therefore greater.

Generally speaking, the greater the area of the surface of a fuel the greater the combustibility. Charcoal with its highly developed cell structure is a fuel possessing a very considerable area of surface per unit of mass, and is characterised by a high degree of combustibility.

Area of surface, again, is closely connected with degree of porosity and with the character and distribution of the pores.

(3) *Character of cell structure.*—(a) Continuity of cell structure. The character of the cell structure of carbonised fuels was investigated by Thorner. He determined the combustibility of various blast-furnace fuels, together with their porosity, and investigated the character of their cell structure by the microscopical examination of sections of the fuels. He found that the fuels which gave the best results in a blast furnace, viz. charcoal and Meiler coke, were characterised by a high degree of combustibility, and consisted, further, of cells more or less regularly arranged, which were joined to one another longitudinally. Furnace coke, on the other hand, consisted of separate unconnected cells, or groups of cells, the cells of which were composed of a dense and vitreous mass which did not allow of the passage of gas through it.

Effect of size of cells.—The dimensions of the cells play a considerable part in the combustibility of a fuel. Practically speaking, the porosity of a solid can be regarded from two aspects, viz. : (1) Cell space per unit volume, and (2) cell space per unit

mass. A coke, for example, may be exceedingly voluminous, and may contain a large number of cells per unit of mass, but owing to its low apparent specific gravity may contain only a small number of large cells per unit of volume. A coke of this type is obtained by customary processes of low-temperature carbonisation; an extreme example is shown in Fig. 1, in which a highly swollen coke is obtained with cells of large dimensions surrounded by very thin walls. The surface presented by such fuel is very considerable, and its combustibility might be high, but on the other hand it is very fragile, and will not withstand severe conditions of handling and transport, and, of course, would be of no use for blast-furnace conditions.

The most desirable fuel would be a fuel as dense as possible, but containing a very large number of cells per unit of mass. Generally speaking, a fuel of apparent sp. gr. 1.2 with a porosity of 50 per cent. would be more serviceable for general purposes than a fuel of app. sp. gr. 0.8 with the same proportion of cell space. In the former case, the cells would be exceedingly small, but the surface presented to the oxidising gases would be so great that the combustibility would be even greater than in the former case.

Industrial possibilities of carbonised fuel of high combustibility.—A brief consideration will show that a fuel of this type offers far-reaching possibilities in connection with modern industrial work. Apart entirely from the special applications to which it would be peculiarly suited, instances of which will readily occur to students of fuel technollogy, it offers very considerable advantages over raw coal in all the principal consuming markets.

Boiler Furnace Combustion

Taking as an example the steam boiler furnace, where the combustion of raw coal in a boiler furnace is a three-stages process and involves (1) the distillation of the volatile products, (2) the combustion of the volatile products, (3) the combustion of the solid carbonaceous residues left after the volatile products have been expelled.

The Volatile Products

The distillation and combustion of the volatile products in a boiler grate introduce factors which are seriously detrimental to the efficient working of a boiler plant. These factors may be summarised as follows:—(1) The interposition of distillation gases between the incandescent mass of fuel in the grate and the boiler cuts off a considerable proportion of the radiant heat transmitted. (2) These gases, and the products resulting from their combustion carry a considerable quantity of sensible heat. To abstract this heat and to impart it to the water in the boiler has necessitated a considerable complication in boiler design in order to increase the efficiency to the fullest possible extent. (3) To obtain the maximum efficiency it is impossible to work the boiler beyond a certain limited capacity without loss of efficiency and the production of black smoke.

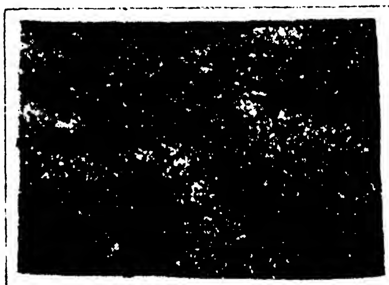


Fig. 6. Pure Coal Briquette, carbonised South Wales Steam Coal (No addition of Coke)

The complexity of modern high-class boiler installations with their mechanical stokers, economisers, super heaters, etc., is necessary almost solely, because of the difficulties of dealing with the distillation products. On the other hand, a free burning carbonised fuel would offer very considerable advantages for boiler furnaces which can be summarised as follows:—(1) no loss of heat in the distillation process, (2) an extremely high radiant heat production in the furnace, (3) the only gases between the incandescent mass and the boiler shell would be nitrogen, carbon monoxide, carbon dioxide, and some oxygen (these are highly transparent to radiant energy), (4) the specific heat of these gases is lower than that of the mixture of distillation gasses, products of combustion, unburnt carbonaceous matter, etc., that exists in a normal boiler grate, and the necessity for elaborate economiser and superheater plants would be considerably reduced.

There is perhaps one other point that may be noted. By careful attention to the structure, a free-burning fuel can be obtained with such a surface area, and such porosity that a very large proportion of the carbon monoxide produced will be burnt on the incandescent surface, increasing very considerably the proportion of radiant heat transmitted by direct radiation.

A fuel of this type produced at a cost comparable with that of coal would offer very considerable possibilities in boiler practice, and would directly result in the following improvements, considerably increased capacity of existing boiler installation, increased efficiency, simplification of boiler design, reduction in capital cost of boiler plant, reduction in labour charges.

A New British Engineering Joint Council

For very many years past it has been recognised that the formation of some federation, or union of the engineering societies and institutions of Great Britain would be useful, and it is interesting, therefore, to record that real progress is now being made in that direction by the formation of an Engineering Joint Council. The four most important institutions—Civil, Mechanical, and Electrical Engineers, together with the Naval Architects, are concerned in this development, and it is explained that other societies may in due course be represented on the Joint Council. The objects of the Council include not only the prevention of unnecessary duplication of activities, but also the improvement of the status of engineers, the better utilisation of their services in the country's interests and the appointment of properly qualified persons to responsible engineering positions. The idea follows that of a similar character, which is more fully developed in the United States, where the four largest engineering societies are associated with a score of smaller ones in the United Engineering Societies, which has a magnificent joint building and a splendidly equipped library, together with many other useful adjuncts.

Some Practical Notes and Observations on Land Type Boilers (ii)

(*Continued from page* 152)

Externally Fired Boilers

THIS type of boiler is not very often now found in England, but it is chiefly used abroad for burning inferior fuel, such as sugar bagasse, etc., as its construction allows a large grate area. There are various kinds of this type of boiler: one type, which is sometimes to be found in old installations, is the Bone boiler.

The two most usual types of externally fired boilers will now be described and for convenience may be called types Nos. 1 and 2, No. 2 sometimes being known as the American type.

Type No. 1 consists of a cylindrical shell with a number of smoke tubes in the lower portion of the shell, running from end plate to end plate. The boiler is set in brickwork so that a furnace is formed under the shell; the products of combustion are led into a brick combustion chamber where they pass through the smoke tubes to the front of the boiler into a smoke box, where the gases divide and return along brick side-flues the length of the boiler to the chimney. Brackets are riveted to the side of the shell for the purpose of carrying the weight of the boiler on the walls of the side flues.

In type No. 2, the shell is similar in construction to that already described, but a smoke box is riveted on to the front of the boiler, and there are no brick side-flues. The furnace and combustion chamber are similar to the first type, but the gases after passing through the smoke tubes are led into the smoke box and thence up the chimney, which is usually of steel, mounted direct on to the smoke-box. Instead of the brickwork taking the weight, four chambers are arranged, two on each side, with steel girders running above the boiler; and steel stay rods drop from these girders and are fixed to brackets riveted on the side of the boiler.

Locomotive Boiler

The locomotive type boiler, usually called "Loco." for short, is, in my opinion, one of the most useful boilers for evaporations up to about 4,000 lb. of water per hour, where space and first cost are of consequence. Loco boilers are made up to evaporations of 8,000 lb. of water per hour, but these larger sizes are not often used.

The Loco type of boiler, as its name implies, is similar to the type of boiler used on locomotive engines: it consists of a barrel in which smoke tubes run the whole length at one end of the shell, the fire box is riveted to it and at the other end the smoke box is riveted, on which a steel chimney is mounted; or, in some cases, the smoke box is arranged as a downtake in order that gases may be led through an underground flue. In this last case the supporting pedestal is made hollow.

Special Features

In spite of its many theoretical defects, in my opinion, the Loco boiler is one of the most popular boilers for small powers and is extensively used in laundries and small factories, etc. One of the chief theoretical defects to which I refer is that the design of the boiler is un-mechanical as regards resisting internal pressure and it is subject in places to very severe stresses; staying is of the utmost importance in this type of boiler.

The Loco boiler's chief advantages may be summed up as follows. It is easily installed, no foundations and no bricksettings are required. It contains a large heating surface and grate area in a comparatively small space. It is a quick steaming boiler and can be forced when necessary; steam can be raised from cold in less than a quarter the time required by the Lancashire type of boiler. The dimensions of the grate not being limited by the size of the barrel, as in the case of internally-fired boilers, the grate can be constructed of such form and such dimensions that any kind of fuel can be burnt; evaporation for evaporation, the weight of this type of boiler is less than others, and hence its suitability for export work and contractors' work.

A defect to be guarded against in this type of boiler is that in some designs the fire-box is carried too high into the boiler barrel, with the object of obtaining greater heating surface; although this may seem at first sight an advantage, it is really a very bad practice, as it brings up the height of the water level, which causes priming.

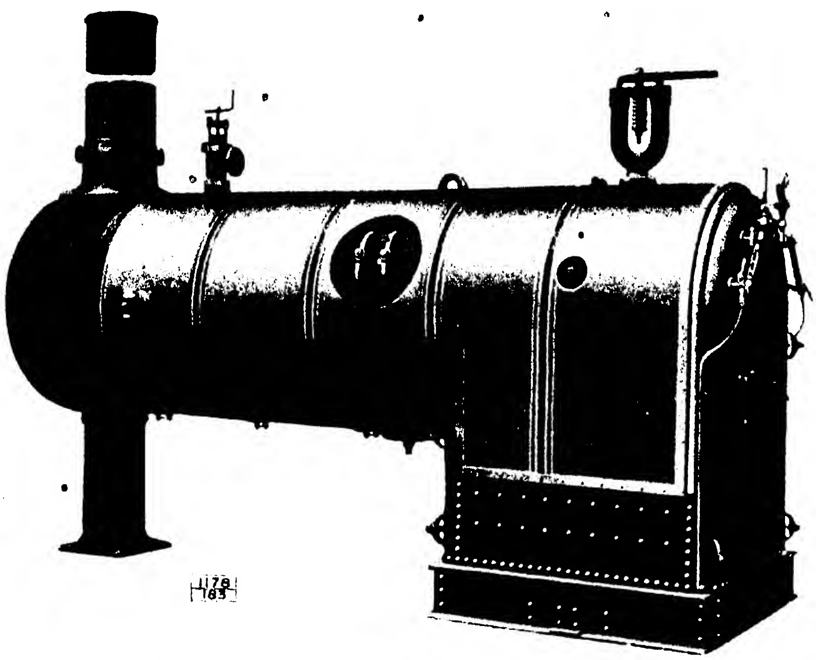
Cleaning of this type of boiler is admittedly difficult and very hard water should not be used, but in actual practice it is surprising how clean the boiler can be kept with careful management and with the use of a reliable boiler fluid.

A modification of the Loco type boiler is that sometimes called the Colonial type boiler, as manufactured by Robey & Co. Limited, of Lincoln; this consists of a barrel like the Loco boiler, but has a circular fire box usually of a larger diameter than the barrel. It is fitted with an internal flue, and the flue and the tube plates are so designed that these can be withdrawn for cleaning purposes. This type of boiler is usually used with the overtype Locomobile engine.

Galloway Boilers

The Galloway Patent Boiler is a modification of the Lancashire type, but varies considerably in detail. This boiler has two short cylindrical furnaces which lead into a larger and oval-shaped combustion chamber, which has from 20 to 35 cross water-tubes, and also from four to six water-pockets at the side of this combustion chamber. The setting of a Galloway boiler is similar to that of the Lancashire type, except that the gases first pass along the side-flues and then return to the chimney by the underneath flue. The reason for this reversal of the path of the gases is the fact that a very large down take would be required to conduct the gases to the underneath flue, because of the great width of the combustion chamber.

Some very good evaporations have been obtained with this type of boiler, but unless properly looked after, trouble is bound to occur with the cross tubes, for these have a tendency quickly to become covered with scale



Locomotive Type — *Robey & Co. Ltd.*

and in many instances become quite solid; this, of course, causes overheating and its subsequent troubles, and the author is not personally in favour of the fittings of Galloway tubes to Lancashire boilers, unless the water used is very soft.

The Galloway boiler is not subject to as much grooving and channelling as the Lancashire boiler, but a seam which often gives trouble is where the furnace is fitted to the front of the combustion chamber; undoubtedly, very great stresses occur here.

Vertical Boilers

Personally, the author does not believe in vertical boilers; they are all fuel eaters and difficult to clean, and, in his opinion, they are only justified, for stationary work, when space available will not permit of any other type of boiler. The most successful types of vertical boiler are undoubtedly the Cochran and the Essex types.

Water Tube Boilers

The water-tube boiler is so named, because the water is in the tubes and the heat on the outside, which is just the reverse in the Lancashire and Economic types.

For single units which are required to give an evaporation of much over 8,000 to 10,000 lb. of steam per hour, undoubtedly the water-tube boiler is practically the only type that is installed for large power station work. The commencement of the popularity of the water-tube boiler started about 1900, and has consistently grown ever since.

There are many types of water-tube boilers and many patents have been taken out in respect to same, but I propose in this paper confining myself to four types which I think are fairly representative, viz.: the Babcock & Wilcox type, the Spearing, the John Thompson type and the Kestner type. Some of these are no doubt familiar, though it is quite possible that the Kestner type is not so familiar at present, but it has some very interesting points.

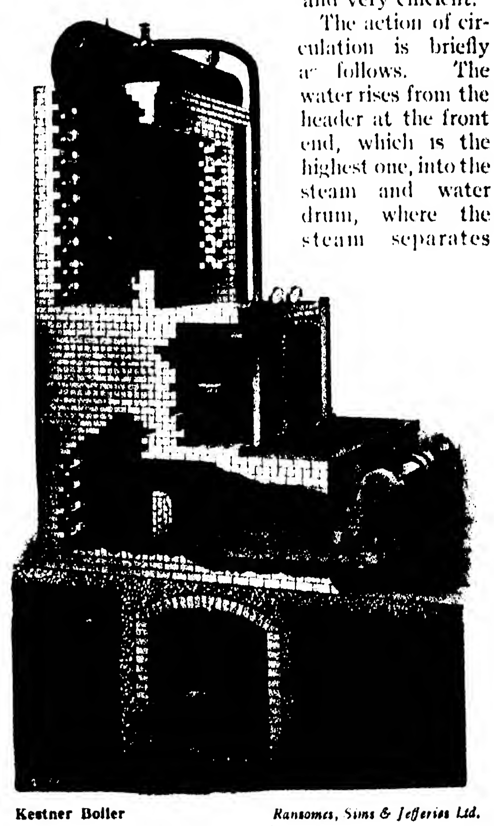
The water-tube boiler is undoubtedly the boiler when large amounts of steam are required to be generated per hour. The ground space occupied is small in comparison with the amount of steam generated, the water-tube boiler is a quick and dry steaming boiler, and it responds very quickly to the demands of overloads and also to the fluctuations in load that are experienced in power station work.

The design of the water-tube boiler is such that it readily lends itself to the fitting of special furnaces to deal with special kinds of fuel.

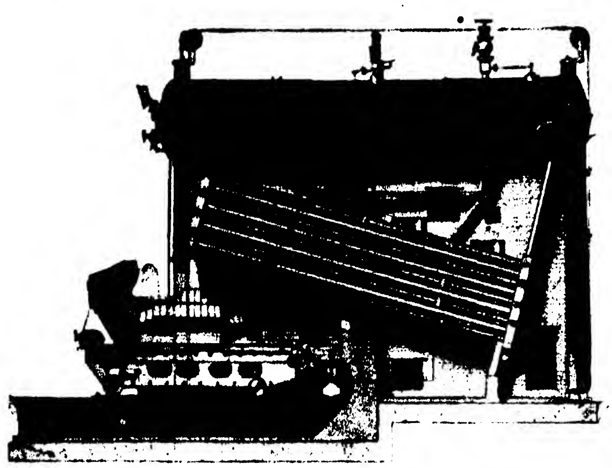
Of course, owing to the smallness of the diameter of the tubes, some form of water-softening apparatus must be used, for much formation of scale in the tubes would cause loss of efficiency and overheating of the tube with consequent trouble and danger.

The Babcock & Wilcox type of water-tube boiler consists of a series of inclined water-tubes above the furnace which are connected to headers at each end, the headers being connected to the water and steam drum by more or less vertical pipes. The headers are so made that the tubes are staggered, thus ensuring the gases being thoroughly broken up and the maximum amount of heat extracted from them, and so a very good and quick circulation is obtained, making the boiler a quick steamer and very efficient.

The action of circulation is briefly as follows. The water rises from the header at the front end, which is the highest one, into the steam and water drum, where the steam separates



Kestner Boiler — *Ransomes, Sims & Jefferies Ltd.*



Water-Tube Boiler — *Babcock & Wilcox Ltd.*

from the water, the remaining body of water returning through the vertical tubes and headers at the back end into the inclined water tubes, where it is again brought into contact with the hot gases and again passes into the steam and water-drum. A mud collector is fixed at the lowest part of the inclined water tube in order to collect matter held in suspension.

The whole boiler is set in brickwork lined with fire brick, the furnace being at the front end below the water-tubes, and baffles are so arranged that the hot gases go upwards, then downwards, then upwards again, and then finally pass to the chimney. The hot gases strike the tubes at right angles, thus being thoroughly broken up.

The entire boiler, with the exception of the furnace, is suspended by wrought-iron slings from iron girders resting on wrought-iron columns, thus allowing the boiler to contract or expand without damaging the brickwork.

The Spearing boiler is of the inclined tube type water-tube boiler. This boiler is made in two types, the longitudinal drum type, and the cross-drum type.

The headers at the front end are connected to the steam drum by tubes in the usual manner, but the headers at the back end are not directly coupled to the steam drum. A large diameter down-comer pipe leads from the back end of the steam drum vertically downwards to a mud drum, the top of which is connected to the lower end of the back headers. This arrangement ensures a good free circulation, and also the impurities are trapped in the mud drum, and so do not reach the headers or tubes. This arrangement of the down-comer pipe and mud drum appeals very much to the author, and he considers it a very sound principle.

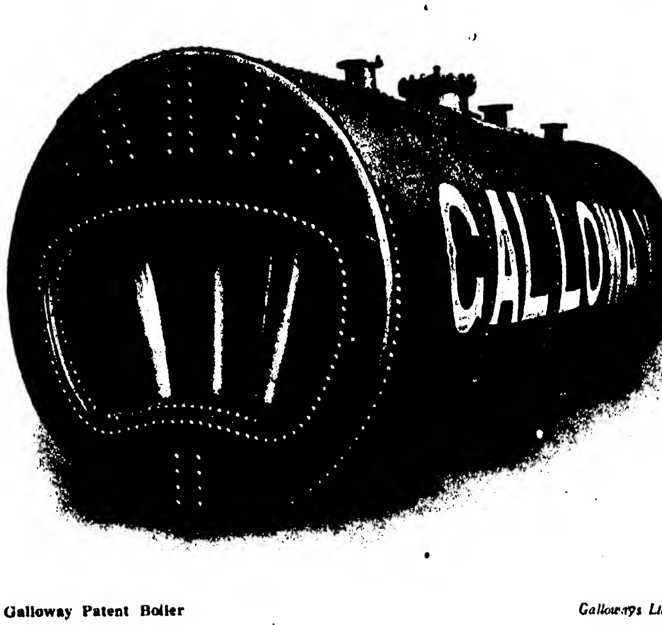
The water-tube boiler as manufactured by John Thompson Ltd., consists of steam drums and water drums connected by groups of tubes, which are nearly vertical and perfectly straight. The steam drums and water drums are connected to each other by circulating tubes.

The whole boiler is set in brickwork and the path taken by products of combustion after they leave the grate is such that they go up and down twice before going to the chimney, thus ensuring the utmost heat being imparted to the water; a very good efficiency is obtainable with this type of boiler. This boiler is not dependent on the brickwork for its support, but it is suspended from girders supported on columns, the lower drum hanging by means of the tubes from the top drum. The tubes in the John Thompson boiler, being absolutely straight, give many advantages over similar types of boilers built on the same principle, but having bent tubes.

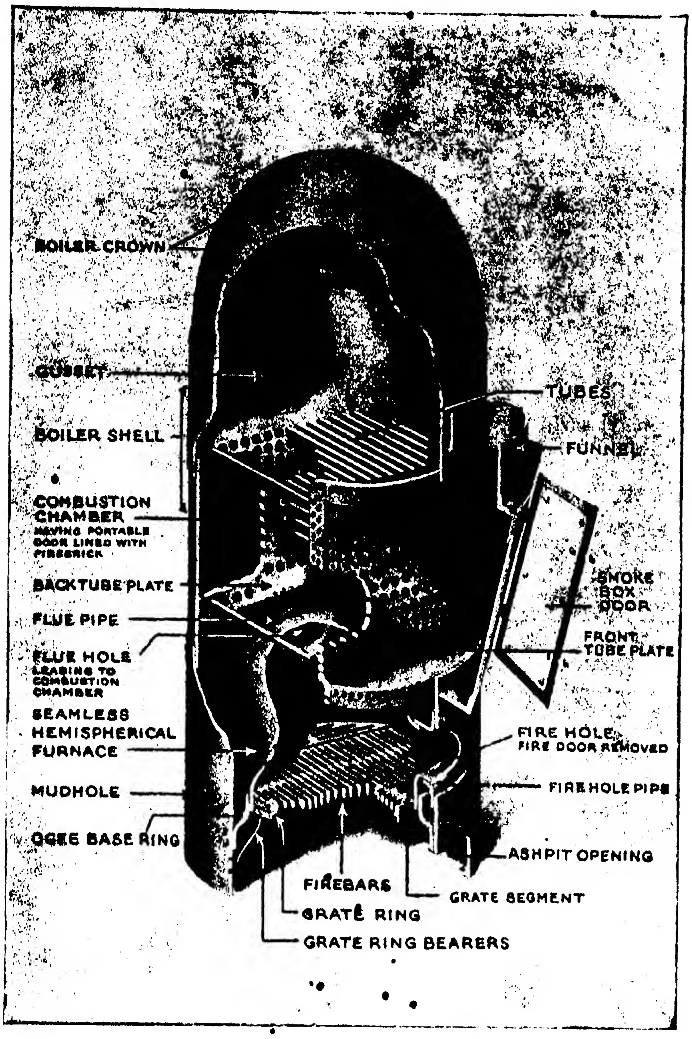
The Kestner boiler is the invention of M. Paul Kestner, the eminent French scientist, and is manufactured in England, by Ransomes, Sims & Jefferies, of Ipswich.

The boiler consists of an upper and lower drum, the two drums being connected by a double row of tubes, which are vertical and quite straight, and, when looking on plan, are so arranged along the length of the drum that they form a continued W.

The ordinary evaporation tubes are either two and three sixteenths ins., or two and three eighths ins. in diameter, but arranged along the longitudinal centre of the drum are some larger tubes of either 3¼ in. or 4 in. in diameter, inside which are smaller concentric tubes, termed circulating tubes, which ensure a very good circulation. This vertical stack of tubes is enclosed in brickwork that resembles a large vertical flue; the grate is built in front of the boiler and the gases strike the bottom of the tubes at right angles, and are then directed up towards the top drum, by means of baffles, in the path of a letter S, making about



Galloway Patent Boiler — *Galloways Ltd.*



Cochran Boiler — *Cochran & Co. (Annan) Ltd.*

seven or eight passes before going to the chimney.

The top drum is supported on a steel staging and the bottom hangs from it by means of the tubes, thus ample provision is made for expansion and contraction.

Some comment may be made on the slipshod way in which many boiler installations are run. The author maintains that the boiler is the heart of the factory and requires quite as much, if not more, skill and attention than the engine, and although there is sure to be a lot of coal dust, there is no reason why the boiler house should not be kept reasonably clean and tidy; in nine cases out of ten where one finds a clean and tidy boiler house, so you will find that the boilers have been receiving careful attention.

It pays over and over again to pay an intelligent stoker a good wage, as intelligent stoking will save pounds on the fuel bill. It is a very erroneous idea that any fool can stoke, because it takes a clever man to become a good stoker.

These remarks apply more to smaller plants than large power stations and the author is glad to see that there is a move in the right direction in larger plants. In some cases firms are employing a chief boiler engineer to run the boiler-house, with the results that by careful management and instruction he has been able able to reduce the running cost of the boiler plant by many hundreds of pounds per year.

MECHANICAL VEHICLES AND ROAD SURFACES

At the recent Paris Meeting of the Institution of Mechanical Engineers, Lord Montagu of Beaulieu read a paper on the subject indicated above. He explained how defective road surfaces increased the cost of operating motor vehicles, and suggested that the time had now arrived when the increasing weight of modern road vehicles should be carried on more than four wheels. As he pointed out, certain systems already use six wheels, with the power plant separate from the carrying vehicle, while the use of trailers is gradually becoming more common. This ensures that the weight on any individual wheel is kept within reasonable limits. In conclusion, Lord Montagu urged that bad roads meant that a nation as a whole had eventually to pay more for the extra cost of its transport, and that this in turn increased the price of every kind of article to the manufacturer and consumer. In order to save this waste there must be more co-operation between roadmakers, designers of road vehicles and road users, to promote economy in the upkeep and improvement of roads, which at once reflects itself in cheaper transport. Otherwise the road and the vehicle alike will suffer, and in the next few years there will be increasing difficulty in finding money for road construction and repair.

The Crossley Convertible Engines for Liquid or Gaseous Fuels

An interesting example of an Engine capable of using either Oil or Gas

THIS type of engine is based on the well known Crossley Cold-starting engine, and by simple and rapid alterations it can be converted to run on gaseous fuels. The engine will also burn motor spirit, including such fuels as petrol, benzol and alcohol. When benzol or alcohol is used the engine works on the gas engine cycle, the fuel passes through an atomiser to the air inlet valve. Under the same conditions as those in use for burning benzol or alcohol, that is to say, with magneto ignition, the engine can run on either town's gas, natural gas, producer gas, coke oven gas or blast furnace gas. By changing the piston, disconnecting the magneto, and connecting up the fuel pump and fuel governor, the engine can be changed over from a gas engine within half an hour to an hour according to the size into the well known cold starting oil engine, when it will burn kerosene, gas oil, petroleum residue, such as "Diesel," and "Furnace" oils, or tar oils and other grades of heavy fuel oils. On the other hand a conversion from any gas to benzol or alcohol is only a matter of a few seconds, in fact can be effected without stopping, as it only means turning on one fuel and turning off the other.

There appears to a great future for this type of engine, not only for use on the oil fields, where natural gas may be available for a portion of the time, while at other times it may be more convenient to employ liquid fuel, but also for general industrial use. Very many buyers of power plant are in doubt as to whether they should buy gas or oil units. Gas engines employing coal in producers are at the mercy of coal strike, whilst the oil engine users are dependent upon the oil supply. The use of a convertible engine gives the engineer several strings to his bow. He may use town's gas, or work a gas producer, or after rapid conversion, employ either a petroleum base oil, or, if necessary, a tar oil. When it is considered that a high efficiency is obtained on all these fuels it will be seen that the user of a convertible engine is in a much sounder economic position than the user of any other type of power unit, and in addition he is doubly insured against stoppages due to strikes, trade disputes, fuel rings, fuel shortages, etc. Further, the cost of working is much less and the continuity of working much more assured than where electric current is purchased from an outside source. It will be seen therefore, that the installation of a convertible engine is a valuable power insurance policy.

Some of these engines were tested in the presence of a well known fuel expert. These engines had cylinders of 11 in. bore by 20 in. stroke, and ran at 230 revolutions per minute. This expert states that the engines developed the maximum load of 44 brake horse power, and a normal load of 40 B.H.P. The load of 44 B.H.P. was obtained with all fuels mentioned, except blast furnace and producer gases, which are, of course, of very low heat value. The engine ran perfectly smoothly and was remarkably silent for an engine of the size. When running on petroleum oil the consumption worked out at .414 lbs. per B.H.P. per hour, which is equivalent to an over-all efficiency of 30.6 per cent. at full load, which is really a remarkable figure for a single cylinder engine of only 40 B.H.P. Running on petrol the engines used .622 lbs. per B.H.P. hour, this higher figure being due to the low compression employed due to the fact that the engines were destined for a tropical climate.

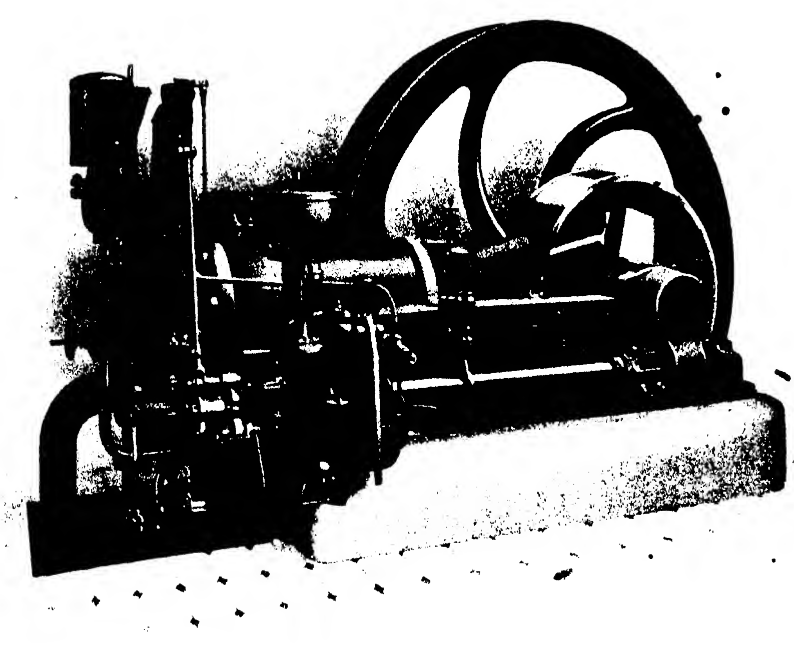


Fig. B.

These particular engines were intended to run on natural gas, but as this was not available for test bed purposes the trials were run on town's gas of 430 B.Th.U.'s heat value, when the consumptions were 20.9 cubic feet per B.H.P. per hour, which is equivalent to an over-all efficiency of 28.3 per cent.

The illustrations given show the engine when running as a cold starting engine (Fig. A), and when running on gas (Fig. B). It will be observed that the alteration is very slight. (Fig. B) shows the engine with the magneto connected up and running as a gas engine.

When running on oil the engine employs no heating device, such as hot bulb, hot plate, etc., firing being obtained solely by spontaneous ignition. This type of engine employing mechanical injection and dispensing with the hot bulb is particularlly suited for the use of the heavier grades of fuel oil generally employed in furnace firing. Its high degree of economy and the wide range of fuels which it is capable of burning should ensure a most satisfactory future for it.

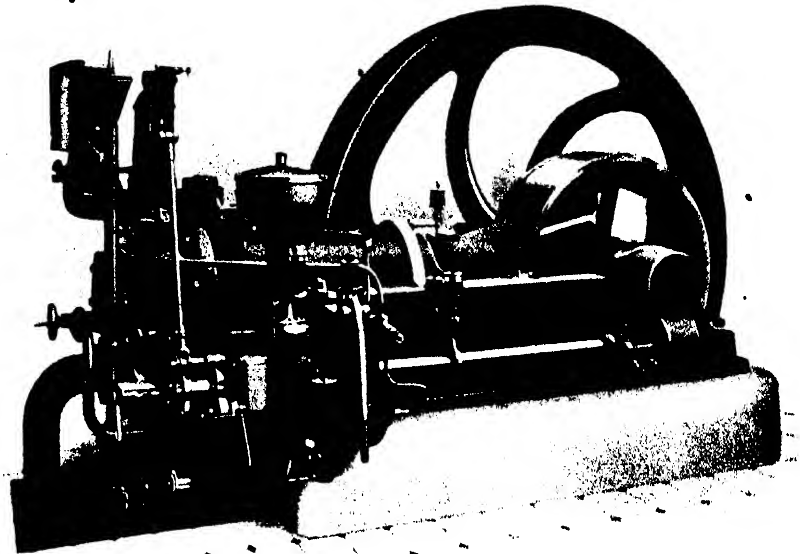


Fig. A.

THE USE OF COKE AS A FUEL FOR STEAM GENERATION

With regard to the discussion that has recently taken place in the American engineering press, with regard to the advantages of coke as a fuel for steam generation, coke—under certain conditions—is a highly efficient fuel for this purpose, and a large number of boiler plants in London, for example, have been burning coke and coke breeze for many years. It is not always realised, however, that the chief factor governing the efficiency of coke burning is the percentage of moisture present. With conditions of careful quenching and storage under cover, the percentage of moisture should not exceed 5-6 per cent. Under these circumstances coke has a heating value of 12,000-12,500 B.Th.U. per lb., with say 12-15 per cent. ash, and it burns with an extremely hot efficient smokeless fire with a high emission of radiant heat, and about 15 per cent. CO_2 in the flue gases. It is possible to obtain evaporation figures of 10 lbs. of water per lb. of coke (and over 9.0 lbs. is quite common), and comparatively easy to work a hand-fired "Lancashire" or "Cornish" boiler plant at 80 per cent. efficiency, and it is an ideal fuel for small vertical boilers. With hand firing and natural—or better steam jet furnace—draught it is necessary, however, to keep a very thick fire with coke, which does not require poking or raking, as with coal, and not more than 20 lbs. per square foot of grate area per hour can be burnt. With mechanical stokers and water-tube boilers, however, the figure can be as high as 30-35 lbs. per square foot per hour, and up to 50 per cent. of coke breeze may be mixed with the coke without reducing the efficiency and rate of combustion figures by more than say 10-20 per cent. Further it may be burnt as pulverised fuel in unit pulverisers. Another advantage of coke as a fuel for steam generation, is that the ash does not form clinker, but is perfectly granular, like sand, so that cleaning out is an easy matter. This seems to be due to the smal amount of sulphur in coke. Unfortunately, however, coke easily absorbs moisture, so that, because of careless quenching and exposure to the weather, the average percentage of moisture is usually 10-12 per cent.

It is also easily possible for coke, and especially coke breeze, to be completely waterlogged and to contain 20 per cent. moisture, in which case the reduction in the efficiency is so serious, both because of the decrease in percentage of actual combustible, and the necessity of evaporating this excessive moisture in the boiler furnaces, that the evaporation figures are only 4-5 lbs. of water per lb. of coke instead of 9-10 lbs. There has long been some vague idea that coke burning corrodes the boilers, but this is entirely erroneous, and many gas works have had cylindrical boilers burning coke breeze continuously for over 40 years without the slightest effect on the boiler.

A Recent Waste Heat Boiler

IN a recent issue we dealt with a number of pioneer installations, when waste heat from different types of gas-works retorts was utilised for steam generating.

We are now able to illustrate one of two boilers recently shipped to the Tokio Gas Works, Japan, by Messrs. Spencer-Bonecourt Ltd.

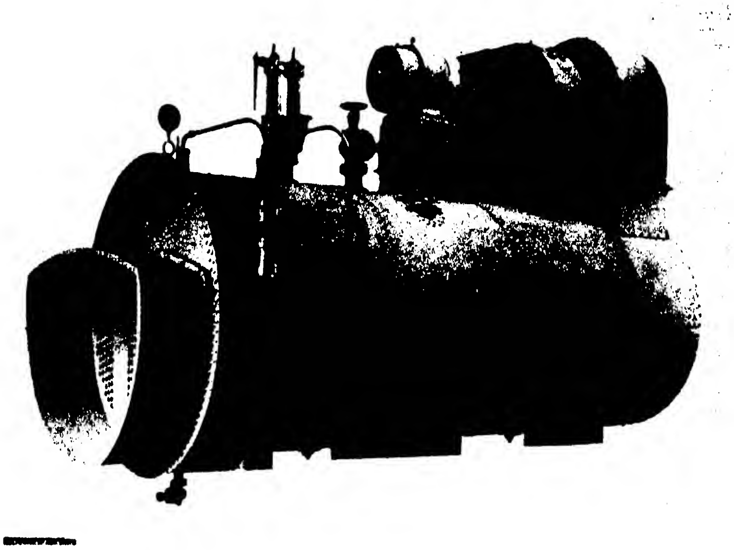
Each of the boiler plants in question deals with waste gases from a large bench of continuous vertical retort settings, and each boiler unit is complete with superheater and induced draft fan unit.

It is interesting to note that the makers employ their patent device for cleaning the boiler tubes without interfering with the running of the plant, as waste heat recovery practice has proved this to be necessary when dealing with dirty gases.

Another feature is complete accessibility of the boiler for cleaning on the water side of the heating surface.

This type of waste heat boiler is claimed to have a tube efficiency of over 90 per cent., and special arrangements are embodied in the design to ensure the correct draft being maintained on the retort settings under all conditions of service.

The boiler illustrated is similar to a number recently supplied to Gas Works, Steel Works, etc., all over the World.



Waste Heat Recovery Boiler for Japan — *Spencer-Bonecourt Ltd.*

EFFECT OF THE WAR ON RAILWAY POLICY

Sir William Acworth, K.C.S.I., who is well known in India, from the fact that he presided over the recent Committee of Inquiry into railway administration, recently contributed a short series of articles on "The Railways." His first article was particularly instructive, and in his inimitable style, he reviewed the changes in railway policy brought about by the war. As he well said, there has been much wavering between private ownership and nationalisation. Whereas England and America, after sampling public management, have gone back to private management, Belgium and Germany, after seriously considering denationalisation, have definitely decided to retain State ownership. The new system of private management is, however, both in England and America, very different from the old, and similarly there is a prospect of radical changes in the methods of State management both in Belgium and Germany. France, on the other hand, has decided to re-lease to a private company the *Ouest*, which it nationalised in 1908, and so again becomes a country of private company management. But in return, the new French law of 1921 makes the already strict control of the State over the companies still more strict. In Canada the State has taken over from private management some 20,000 miles of railway. In Holland, the State which hitherto owned the railways, but leased them to companies has now entered into partnership with the companies by acquiring the majority of the shares and, consequently, the right to appoint a majority of the board of directors. It may further be stated that Spain proposes to follow the example of Holland.

The idea of partnership between public authorities and private investors is, says Sir William Acworth, not at all new in connection with enterprises "affected with a public interest"—to use an expressive American phrase. It worked successfully for many years on the Mexican Railways, and was applied before the war to numerous tramway, electric light and power, and similar undertakings by the German municipalities, while it is being further developed in that country at present. It would seem from this brief review of the general railway position in many lands that we are still far from the happy state of having found the best method of control, and India would, therefore, be well advised to move slowly.

The Atritor

Blyth's Patent Self-Contained Coal Dryer, Pulveriser and Blower

CONSERVATION of fuels is perhaps a matter that will more vitally concern the next rather than the present generation, but it is one that ought to occupy a prominent place in our scientific and industrial research work to-day.

Cheapness of production, however, is an important present-day problem and one to which we must bend our untiring energies if we are to maintain our prestige and position in the world's commerce. Not the least factor in the cost of production is the item of fuel costs. With individual plants consuming over a thousand tons of coal per week, and others using hundreds of tons of oil, the cost of fuel must bulk very largely in the annual balance sheets.

Of the various fuels available, pulverized coal would seem to offer very many advantages from the point of view of cheapness. The costs of different fuels at the present time are approximately as follows :-

Coal (nuts)	... ...	21/- per ton
Fuel oil ...	... ...	£6 ,,
Small slacks (smudge) ...		4/- ,,

These figures are for use in England only, and are for June, 1922.

In the U.S.A. pulverized coal as a fuel has received much more consideration than has been the case in this country, and it has been widely adopted in many large power house plants.

At the River Rouge boiler plant of the Ford Motor Co., the four supposed largest boilers in the world are fired by pulverized coal and blast furnace gas. This method of firing was only adopted after an exhaustive survey of all possible types, and it would seem to indicate that there are potentialities in powdered coal that will well repay the careful consideration of fuel users.

In the cement industry it has been standard practice for many (about 60) years for firing rotary kilns. Whatever may be the impression regarding this fuel for other applications, such as boiler houses and furnaces, there can be no two opinions on its superiority for cement work.

In the utilization of powdered coal as a fuel there have been in the past both advantages and disadvantages. Among the latter were the costliness of the pulverizing plant, the inadvisability of storing the powdered product for use, and difficulty in dealing with the ash. If these can be eliminated, or at any rate considerably depreciated, there would seem to be a wonderful future for powdered coal.

The advantages it claims are cheapness of fuel, extraction of most of the heating value, low labour costs, and the fact that low grade coal can give good results.

In the past a powdered fuel plant has not only been costly to instal but equally costly to maintain and run, entailing, as it does, a coal dryer, with its auxiliary furnace, a tube mill or other pulverizer, elevators, conveyors, separators, bins and bunkers for storage, fans, etc.

With a new invention named the "Atritor," it is claimed that all the disadvantages mentioned above are eliminated. This machine dries, granulates, pulverizes to any degree of fineness and delivers the fuel into the combustion chamber all in one continuous process as and when wanted, at any desired rate of delivery without any auxiliary plant whatever, other than a feeding arrangement for the coal.

The "Atritor" is the invention of Mr. Chas. E. Blyth, and is now in constant use at his cement works at Stockton, near Rugby, Messrs. Chas. Nelson & Co. Ltd. The sole licensees and manufacturers are Messrs. Alfred Herbert Ltd., of Coventry, to whom all inquiries should be addressed.

The first "Atritor" was put into commission about twelve months ago (June, 1921). During the intervening period this machine and two others have been subjected to very rigorous tests in the course of much experimental work, and the stage has now been reached when the machine can be placed on the market under a guarantee. The machine as designed is known as the No. 10 size, and it is guaranteed to give, with an actual power consumption of 30 H.P., an output of 1,800 lb. of coal per hour pulverized from ¾ in. lumps to a fineness such that 95 per cent. will pass through a British Standard 100 × 100 mesh screen. A larger machine is being designed at the present time, while a smaller machine is also in contemplation.

A typical "Atritor" installation, as applied to two 140 ft. × 8 ft. rotary cement kilns consists of two "Atritors" driven by 40-H.P. electric motors, each with a 10-ton raw coal hopper for feeding, and an elevator for keeping the hoppers full, with a screw conveyor from the elevator to one hopper. It is recommended that 40-H.P. motors be installed for driving this size of machine, though it will give full output when grinding coal not exceeding ¾ in. in any direction at 30 H.P.

A similar installation is capable of burning over 800 tons of cement per week. It is, however, advisable to have a third "Atritor" as a standby in case of breakdown through any cause. It is a simple matter to arrange the delivery pipes with flap valves so that any of the machines can deliver its products at the point desired.

The cost of pulverizing coal by the "Atritor" system at Stockton is about 2/7 per ton, while by the old installation it was about 5/3 per ton. There are very few plants which operate at such low cost, the majority ranging round 6/- to 10/6 per ton.

Another decided advantage of the "Atritor" system of burning the fuel immediately is the fact that a lower grade of coal can be used with consequent decreases in cost. With the old type of plant a large part of the volatile combustible matter in the coal is lost during the drying operations and storage. The approximate difference between the lowest grade coal it was possible to utilise by the old system and the coal which can

be burned quite satisfactorily by the "Atritor" system is 10/- to 7/6 per ton delivered at the works. The total costs for fuel burnt in the kiln, that is, delivered at the works, handled and pulverized and propelled into the kiln, are therefore 15/3 per ton by the old installation, against 10/1 per ton by the Atritor.

The advantages claimed for the "Atritor" system for pulverizing coal may be summed up as follows :-

1. It is a small, self-contained unit for drying, pulverizing and propelling the fuel direct into the combustion chamber ready for burning, in one continuous process.

2. It will deliver any quantity at any rate desired, as and when wanted, up to its capacity of 1,800 lb. per hour.

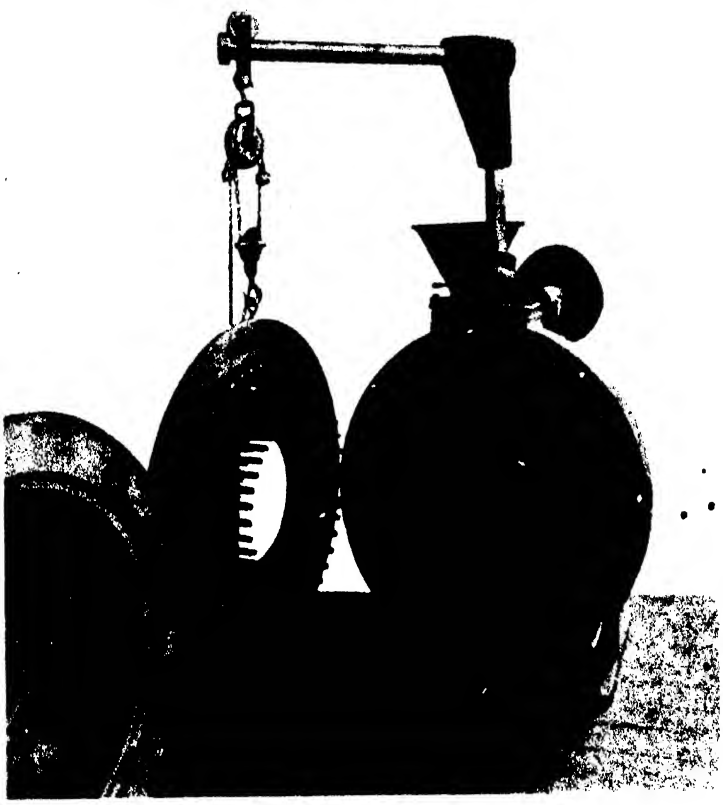
3. It is continuous in action, and dispenses with the necessity for storage bins.

4. It can be started and stopped at will.

5. The drying and pulverizing go on together, and the product is burned immediately without opportunity to absorb moisture after pulverization. This is important, as powdered coal is extremely hygroscopic.

6. The whole of the combustible contents of the coal pass into the furnace, and are burned. There is no opportunity for the volatiles to be lost. This is a very important point, as considerable waste of volatiles takes place during drying and storage under the old system.

7. It entirely supersedes the elaborate, expensive and dusty plant hitherto employed for the purpose.



Interior of Atritor — *Alfred Herbert Ltd.*

8. There is no necessity for any subsidiary plant other than a feeding device for the raw coal.

9. The cost of the installation is low. The power consumed is low. The cost of maintenance is extremely low. The labour cost is low.

10. It is entirely dustless in operation.

11. The moisture contents of the coal make no difference to the working of the machine or to the resultant product.

12. The hot air supply for drying can be drawn from any convenient source of waste heat.

13. No smoke or soot is formed and no combustible matter left in the ash.

14. Pulverization may be carried to any degree of fineness desired.

15. A high temperature can be obtained very quickly.

16. By the addition of a minute amount of paraffin (a patented process), .07 per cent. by weight of coal pulverized) the time for heating up is reduced by 75 per cent. A rotary kiln is ready for use 40 minutes after lighting up.

17. The addition of paraffin also enables coal which is unburnable when ground by other means to be successfully burned by this system.

18. There is no heat wasted nor waste of fuel when damping down.

19. There are no screens used, and therefore no clogging of material.

20. An efficient metal separator is incorporated in the inlet end of the machine. This dispenses with the use of a magnetic separator.

All these are claims which can be substantiated at any time. They are claims which must command attention by reason of the economy of fuel consumption promised.

As previously stated, the coal used at Stockton costs about 10/- per ton pulverized and ready for burning. It is known as small slacks or smudge, for which the present market price is from 2/6 to 4/- per ton at the pit head. Yet this inferior quality of coal gives as good results as coal costing four times as much, merely by the addition of paraffin in drops.

The addition of paraffin during pulverization has produced such almost extraordinary effects that the process has been patented. The requisite amount for firing up is .07 per cent. by weight of fuel burned, or about 1½ pints per hour to 1,800 lb. of coal. The paraffin can be shut off when full heat is attained, or it can be kept on when pulverizing very inferior coal, in order to assist in maintaining the temperature.

It is interesting to note that during the coal strike in the middle of 1921, rotary kilns were successfully heated by coal dust from the grass-grown refuse heaps by the slight addition of paraffin mentioned above.

The average analysis of this refuse coal was as follows :—

Moisture varied from 9 to 20 per cent. according to position on the heap and time of using. The dried coal gave on the average:

Volatile combustible matter	15.2%
Fixed carbon	30.6%
Ash	54.2%
Heating value B.T.U's. per lb.	4,356

The mechanical features of the "Atritor" are shown in the illustrations.

It consists generally of:—

(*a*) A hopper with variable screw feed driven by cone pulleys and worm gearing and lever operated slide, for regulating the flow of raw coal.

(*b*) A coal chute and metal separator in which any material of heavier specific gravity than coal is thrown out and thus prevented from injuring the machine.

(*c*) Hot and cold air supply ducts.

(*d*) A casing with fixed pegs of extremely hard metal in concentric rings on both sides.

(*e*) A rotor disc with similar pegs on each side and rejector pegs on one side.

(*f*) A suction and blower fan cased in a scroll. In the scroll are auxiliary air ports.

The coal feeds through the slide and screw and falls towards the centre of the machine, where it is met by a strong current of cold air which is being drawn through an adjustable opening in the front of the machine.

The air draught is adjusted to the amount of coal feed, so that all the coal is pulled into the machine, but anything heavier than coal rejected, falling down to the air inlet, thus dispensing entirely with the necessity for a magnetic separator.

The pull of the fan and centrifugal force throw the coal through the intermeshing rings of pegs in the first disintegrating chamber, called the First Effect.

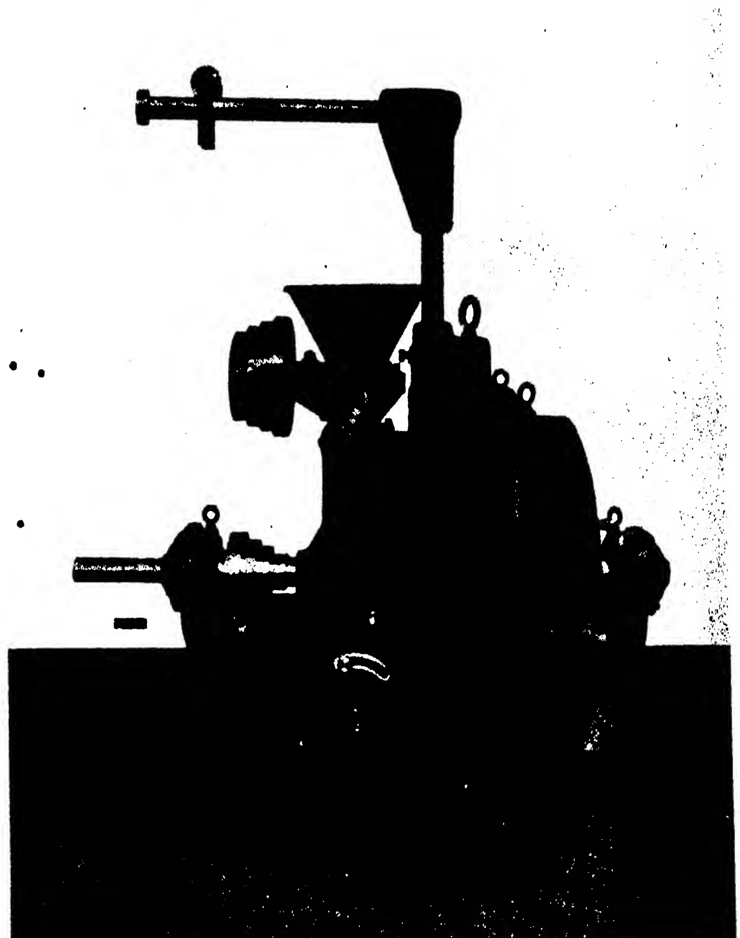
The coal particles are then drawn by suction towards the centre again through the chamber known as the Second Effect. It will be noticed that the rings of pegs go completely across the First Effect, so that the coal has no loophole to escape their smashing action. In the Second Effect, the rotating rings of pegs only go across half the chamber, leaving half the volume free except for stationary pegs. The innermost ring on rotor is composed, however, of pegs which go completely across the chamber and enter a recess in the casing on the other side. This ring acts as a rejector for coal particles that may be still too large for use. In addition, a set of eddy currents are set up towards the centre on the side of the casing and towards the periphery up the side of the rotor disc. The circulation thus set up in the Second Effect completes the pulverization until the particles of coal are so impalpable that they are drawn by the fan and propelled into the furnace.

For full capacity of 1,800 lb. per hour with only 5 per cent. residue on 100 × 100 screen, the slide under the hopper should be full open and the screw feed on the fastest rate. Hot air should be drawn in at a temperature of round about 450 deg. to 600 deg. C. At this temperature coal of a high moisture content will be completely dried in its passage through the machine. The auxiliary air ports in the casing on the delivery side should be shut.

If for any purpose the required output is to be less than the above, the slide should be closed first and the cold air inlet regulated so that no coal is rejected by the metal separator.

For a still smaller output the screw should feed at a slower rate, and the slide worked in conjunction. The cold air will have to be adjusted until coal is not thrown out by the separator. This may then necessitate the opening of the auxiliary air ports to give sufficient air for combustion.

The above fully explains the theory and mechanism of the "Atritor." So far it has not been applied to any other use than the firing of rotary kilns, so that data is not available regarding the firing of boilers, locomotives and furnaces.



General View of Atritor

Alfred Herbert Ltd.

ORGANISATION

Conducted by HARTLAND SEYMOUR

THIS SECTION DEALS WITH WORKS MANAGEMENT AND ORGANISATION, THE TRAINING AND WELFARE OF THE WORKERS, AND WITH THE ADVERTISING, SELLING AND MARKETING OF GOODS

Methods of Remuneration

THE chief point to remember in any wage payment system that may be adopted, is that the unit cost of production is the one essential factor in any commercial or industrial concern. That is to say, whether a man is paid so much per hour, per day, or per piece, is entirely immaterial. What does matter is the percentage occupied by wages in the final cost of a product. Let time or piece rates be as high as they can, as long as production costs are kept down. This point is illustrated by the fact that in some of the best organised industries, wages are highest though production costs are lowest. Conversely, in the worst organised factories wages are lowest where production costs are highest.

The usual basis of wage payment systems is the time rate of calculation. A worker receives so much per hour, per day, per week, per month, or per year, depending entirely on his trade or profession, even though piece rates or payment by results systems are also in force. That is to say, sometimes a time rate wage is guaranteed to the worker, while this may be supplemented by his own efforts on a piece rate basis.

Though piece rate systems may be in force in a works, there are certain instances where time rates are inevitable. For instance, on the administrative side, managers, foremen and the like; again, in some of the skilled trades, fitters or patternmakers, and also in the unskilled occupations present in every factory, *e.g.*, cleaners, oilers, labourers and watchmen. These grades of labour must be paid by time, even though they may participate in a payment by results or collective bonus scheme such as in the Priestman plan.

Naturally, such a basis on which to pay wages is open to considerable abuse, and suitable supervision must be undertaken by the manager or owner to ensure that he is getting, anyhow, some return. In other cases, of course, the return is assured by the presence of an adequate amount of goodwill.

The commonest form of abuse of time rates is, of course, deliberate slacking. A worker may sign on, and, if he is an experienced hand at the game, just do enough work to retain his job, and making a point of doing it when the instrument of supervision is in the immediate vicinity; at other times he enjoys himself, and interferes with his neighbours. Such a type has an extremely deleterious effect on the rest of the shop. Not only does he distract their attention, but other men, normally good workers, will very likely say to themselves: What is the use of doing our best and working hard, when X (the delinquent) still holds his job and gets the same wages for doing next to nothing? And sometimes they follow X's example.

Simple time rates, of course, offer no incentive to a skilled workman to improve his quality or his quantity. The unskilled man has not much inducement, except the fear of being fired, and the time rate for him calls for a more or less efficient discharge of his duties, but for no special endeavour. The skilled man on time rate alone will not increase his work or his endeavours unless out of love for his craft, goodwill for his employers, patriotism or hopes of advancement. Material inducement is there very little unless some system of piece rate or bonus is imposed upon the original time rate basis.

On the other hand, since time rates are based upon the time-keeping system, fines may be introduced to promote good time keeping, that is to say, workers may be allowed a certain latitude, say a total of time lost of 10 or 15 minutes per week, but over that figure they are subjected to fines. This system may, of course, promote good time keeping, but this does not necessarily involve good work and high production.

In general, the system of payment by time alone, which is, of course, unavoidable for a comparatively large proportion of workers, provides no direct stimulus for increasing either the quantity or the quality of the work done. As a result some men will inevitably keep well within their capacities, so as merely to retain their jobs; while good men have the quite legitimate complaint that extra exertion and better quality work is accompanied by no increased reward.

On the other hand, payment by time has this advantage over payment by the piece, and that is that the uncertainty of wages, inevitable in the latter, is absent in the former system. This uncertainty may even promote such an anxiety in the worker as to spoil his or her work.

If output records are kept for each operator, then some distinction becomes possible, and a difference in wages can be made, and it is apparent which workers have exerted themselves sufficiently to justify an increase in remuneration.

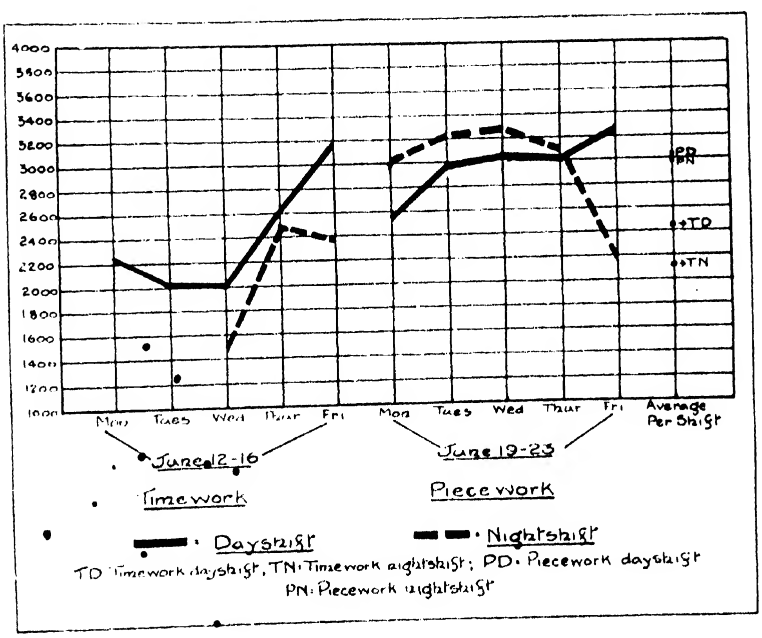
Perhaps the most satisfactory system under time rates is payment on day rate basis, especially in small factories. Here, where each man is known personally to the management, the system of paying out each week the wages due is simplified, and no lengthy explanations are necessary, as is sometimes the case in piece work systems. Owing to the fact also that there is no incentive to the men to hurry unnecessarily, there are less spoilt parts, and the system of inter-operation inspection need be less rigorous.

Payment on a daily basis can, of course, be applied to non-productive workers as well, for instance men in

charge of electric trucks, crane operators, and power plant operatives.

The other chief system of wages payment is the piece work system, which is divisible into a large number of variations of the original payment of so much per piece done.

There can be no doubt but that some system of piece work does, in most circumstances, tend to increase output. This is very well illustrated in Fig. 1, which is based on figures taken by a committee of investigation into various systems of wage payment during the war.* In this chart the daily output of seventeen girls drilling fuses is compared. For the first week these girls were on time rates, the following week they were put on a piece wage. The consequent rise in output is at once apparent, amounting to 24 per cent. over the day shift, and 40 per cent. over the night shift.



An important point to remember is that whatever system of piece rate is adopted, it should be clearly explained to the workers. This should be done so that any man possessed of average intelligence can calculate what wages are due to him, and just what he will receive for a given extra effort. Says Captain Agnew, after investigating the conditions of employment of a large number of men:

"Mistrust, discontent and misunderstanding are frequent among employees, who imagine that they are being exploited, when, as not infrequently happens, they are unable to estimate for themselves their exact earnings. When wages are paid by the ton or by the piece, the method is clearly understood; but when payment is made by some decimal of a total output unknown to the workers, by a share of a sum allotted to a large group of workers, or by a varying piece rate with a bonus added, the calculation is either impossible or too complicated for the wage earner, and suspicion as to its exactness is prevalent, at least among adults indeed, the wages department itself often seems doubtful about the exactness of the methods."

In the simple piece rate plan, a worker obtains so much per piece finished. Thus, in an eight-hour day, if a worker produces no pieces he receives nothing. Suppose, then, a rate of x pence per piece is decided upon. Then if a worker produces 50 pieces in 8 hours, he will get 50 xd. If he produces 100, he will get 100 xd. Thus it is obvious that the curve of wages earned is a straight line when the rates are the abscissae and the number of pieces constitute the ordinates. Thus, in such a curve, the equation is $A = x B$, where A is the wage, x the price per piece, and B the pieces produced within the 8 hours.

The more usual system, however, is where a certain time rate is guaranteed, whatever the men produce, with the understanding that a certain number of pieces must be produced in that time, while any pieces over this minimum are paid for on a piece rate basis. Thus, if in an eight-hour day 10 pieces are standard, and a worker is guaranteed 100d., then if he produces 1 piece he receives 100d., or 100d. per piece; if he produces 5 pieces he still receives 100d., or 20d. per piece, and so on for every piece up to 10. Beyond that he may receive, say, 5d. per piece above 10. Thus for 11 pieces he will receive 105d., and so on.

In the premium, or bonus, or premium bonus systems, the piece rate diminishes to a finite minimum. Thus, suppose, as in the last case, 10 pieces are standard, and 100d. the minimum wage. Then the man will receive the same wage until his output is over 10 pieces. Suppose for any number over 10 he receives 3d. per piece. Thus if he produces 20 pieces he will get 100d. plus (10 × 3)d. = 130d., or 6.5d. per piece. If he produces 30 he will get 100d. + (20 × 3)d. = 160d., or 5.33d. per piece, and so on. In this system the rate per piece does not diminish indefinitely; it cannot fall below 3d. per piece. Take an extraordinarily large sum; suppose he produces 1,000 pieces, then his wage will be 100d. + (990 × 3)d. = 3,070d., or 3.07d. per piece.

This system can be expressed algebraically. Suppose x to be the price paid per piece of the total (including the standard) production; let A be the minimum wage; B the number of articles beyond which the piece rate is paid, *i.e.*, the standard output; let y be the piece rate; and let C be the output in excess of B. Then

the man's total output is B + C

$$\text{Then } x = \frac{A + yC}{B + C}$$

Thus the total earnings of the operator on this system increase indefinitely, while the piece rate falls with increased production, but never below y, the piece rate beyond the standard output.

There are, of course, various modifications of this system, more or less

(*Continued on page* 232).

TRANSPORT

Conducted by "M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH THE MANAGEMENT AND CONTROL OF RAILWAYS

Goods Handling by Mechanical Appliances

(Abstract of a paper (with comments thereon) read by Mr. C. Bentham, M.Inst.T., at a recent meeting of the British Institute of Transport.

ONE of the special points I have tried to emphasize in the many contributions I have had the pleasure of contributing to the columns of INDUSTRIAL INDIA, has been the urgent need for eliminating as far as practicable the unproductive labour involved in handling traffic at any one location. The transport of commodities from place to place has a distinctly productive value, but the transfer at a specific location such as a port or railway freight terminal is essentially unproductive in that it adds nothing to the value of the commodity. It is, therefore, of paramount importance that handling costs should be reduced to a minimum, and in the endeavour to develop machinery to supersede manual labour, and so not only expedite handling methods, but cheapen the working costs, a few firms have specialised on this subject and have, it must be admitted, achieved considerable success.

A leading firm in Great Britain is Messrs. Henry Simon, Limited, of Manchester, whose extremely efficient grain handling installation at Manchester Docks, was the subject of a special article in this journal some time ago. Any pronouncement on labour saving by the use of mechanical appliances by them is, therefore, of importance, and for that reason I give in this article a summary of the valuable paper recently read by Mr. C. Benthan, Managing Director of Messrs. Henry Simon, Limited, on the subject of goods handling by mechanical appliances.

Losses at Terminals

Mr. Bentham opened his paper by reference to the question of transportation generally. He pointed out that there could be little doubt that the existing methods of transporting commodities from place to place, long distances apart, were doubtless as cheap as it was possible to realise under present-day conditions. On the other hand, the fullest use of the facilities provided for such transportation was dependent upon the expedition or otherwise of terminal work, both in connection with the steamship, the railway and the motor vehicle. That terminal functions have not, speaking generally, advanced at the same pace as transport functions in the larger sense is admitted by all sufficiently versed in the subject, and, as Mr. Bentham well said: "It is clear to anyone who has given much attention to the full utilisation of the existing means of transportation that the *greatest avoidable loss occurs at the terminals.*" The italics are mine, as this definite truth cannot be too strongly stressed. I could quote several instances to show how terminal capacity has so detrimentally effected line operation in the case of railway transport that in due season an absolute "block" had to be imposed on forwardings until the terminal could be freed from its congested state. That naturally represented a considerable loss, in more than one direction, and is but one example to show how important it is to have the terminal arrangements fully proportioned to the capacity of the transport link, be it rail, river, steamship or motor vehicle.

Dealing with losses at terminals Mr. Bentham rightly points out that there should be little hesitation in effecting improvements at terminals, because of the fact that these can be effected for a relatively small outlay, compared with the original cost of the structure and its equipment. He might have added, as he infers, that there is the additional factor of cheaper working from the moment the improved appliances are brought into operation, so that the improvements only mean the provision of the necessary money; they will soon give full value for the outlay. The author also urges, and my own experience confirms his views, that it is curious how little attention is paid to the effective use of mechanical appliances in terminals, the general rule being to put down appliances and leave them to the workmen to work them in any manner they think fit. This is not good practice. "Effective management will frequently obtain good results from unsuitable appliances, and the combination of good management, good appliances and good will produces astonishing results."

Traffic Handling at Ports

In view of the fact that unnecessary detention of a vessel is a costly business, any factor tending to more economical loading or unloading is of great importance. Naturally, the handling appliances required in any particular port are determined by the classes of traffic to be handled and the type of vessels to be dealt with. In Mr. Bentham's opinion, the provision of vessels specially suitable for economical loading and unloading has not received the attention it deserves. General cargo vessels spend on an average 50 per cent. of their time in dock when they are fully occupied, and it is evident that this is the loss that must be attacked to obtain a greater return from a given tonnage.

For handling mixed cargoes, cranes are the most usual mechanical appliances used, and where a variety of articles have to be stowed it is difficult to imagine anything more suitable. Where, however, large quantities of one article are to be handled, continuous methods can be applied for carrying the articles into the vessel, or unloading them. The most effective continuous method so far adopted is the Donaldson elevator conveyor, which can be used advantageously for sacks, smaller sized cases, carcases, etc. An ideal arrangement making for more effective work, would be to dump all packages on to slow moving conveyors for transference from the ship to the transit shed where they would be sorted and, as necessary, distributed to stores, or to railway or road vehicles. Under this arrangement it would be possible to have the warehouse built well away from the quay, leaving the quay space clear for cranes, railway tracks, etc. Practically no extra cost would be involved under this system as the extra cost of conveying 50 or 100 yards is very little, and the handling costs are the same in both cases.

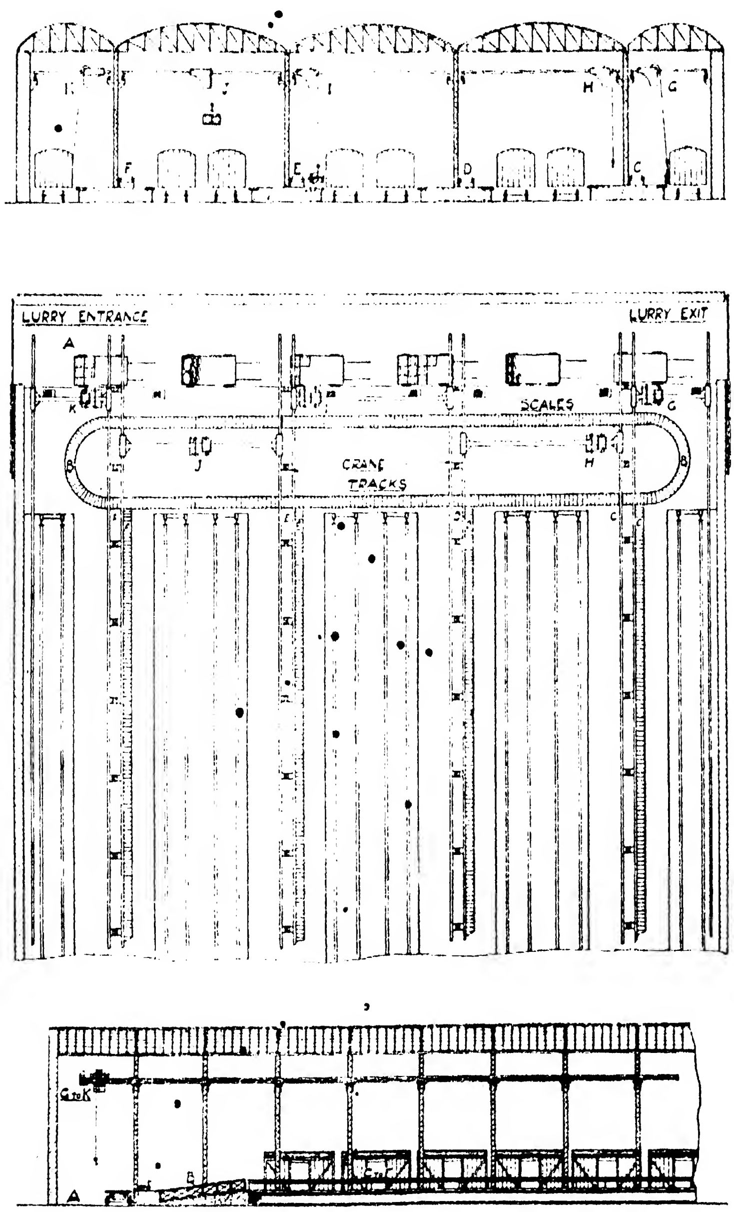


Fig. 2.—Plan and cross sections shewing proposed arrangement in goods depot for handling by electrically operated conveyors and overhead transporters.

INDUSTRIAL INDIA

In the planning of warehouses it is Mr. Bentham's belief that general transit sheds could advantageously be brought more on to the lines existing in grain warehouses, and he gave a brief description of a scheme worked out for an existing transit shed, at a large port, indicating the comparative cost of labour under existing conditions and after the introduction of machinery. The cargoes to be dealt with comprise general American produce, four-fifths consisting of normal-sized packages weighing under 3 cwt. per package, traffic eminently suited for mechanical handling. The scheme deals with the traffic from the ship's side after being lifted out of the holds and placed on the quay either by crane or ship's gear, and shews the conveyance to, and recept in transit shed; and delivery from transit shed to rail or other vehicle. Taking as a basis 2,000 tons of American produce, handled without mechanical aids, 170 to 200 men were employed on the quay and they handled 650 tons per day, whereas with the introduction of machinery this weight of traffic could be handled much more expeditiously by 100 men as a maximum.

A Proposed Scheme of "Machinery" Handling

The diagram in Fig. 1 gives a good general idea of the lay-out of the machinery proposed. It consists, as will be seen, of a circular-ended conveyor running round the centre of the transit shed, and fed by portable conveyors running from the quay, and delivering either inside or outside the circle in the transit shed, or direct into railway wagon. The following is a guide to the diagram :—

A.1/4.—Represents four portable tables receiving the packages from the cranes—four men at each of these points feeding on to portable machines.

B.1/4. Represents four sections of portable conveyors feeding circular conveyor two men at each of these portables feeding on to main conveyor.

C.—Represents the circular conveyor.

D.—Represents the conveyors delivering to railway wagon—one man taking off main conveyor at each point.

E.—Represents position of two men in each railway wagon—taking off portable conveyor, the end of which is raised to enable the packages to be easily taken off.

F.—Represents sets of two men in various positions inside and outside the

ring for taking off the circular conveyor at the nearest storage point.

G.—Represents sets of three truckers to deliver to stack.

H.—Represents four stackers at different points.

This scheme allowed for the simultaneous discharge of four hatches and receiving on to transit shed at four different positions, and delivery to three railway wagons at the same time. The total number of labourers required is 60, plus four lotters and seven checkers, making a total of 71 men to receive, house and deliver with machinery. With an allowance of a further 25 men for trucking the heavier packages and stowing outside the circular conveyor, there is a total of 94 men required for quay service.

a diagram showing a scheme of conveyors that would have the effect of expediting handling and economising cost. I do not propose to elaborate this phase unduly, for it is my intention in an early issue of INDUSTRIAL INDIA to deal on a comprehensive basis with the question of railway freight terminal working in the light of British, Continental and American experience.

In the scheme illustrated the lorries would enter at position marked "A" and "set up" eight or ten at a time alongside the receiving room, the floor of which would be at lorry level. The goods would be discharged from the lorry, checked and weighed and after being marked as to destination would be placed on the circular-ended conveyor marked "B." this method would speed up the work, reduce the labour costs and ease the labour of the men employed. For packages of a heavy and bulky nature overhead electric travelling cranes running the full length of the building should be introduced. These cranes which should be of, say, 20 cwt. capacity, are shown in the sketch under the letters "G," "H," "I," "J," and "K" and would, of course, convey traffic direct from road vehicle to wagon and vice versa.

While the outlay on such a scheme as that suggested would naturally be considerable, there can be little doubt that, once installed, large savings would be effected on labour account. In the sketch plan the width of the conveyor in proportion to the platform width has been exaggerated,

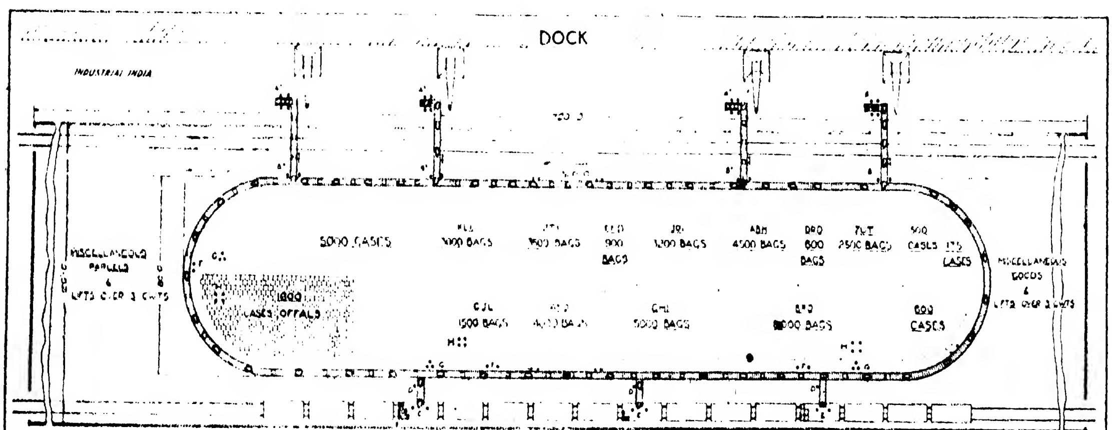


Fig 1.—Plan showing proposed method of arrangement on quay and in transit shed for the handling of general merchandise by electrically operated band conveyors

Assuming there was no increase in speed of working, though in practice there would be considerable, the labour cost, with machinery, would be no higher than 1s. 9d. per ton for quay services as against about 3s. 2d. per ton for purely manual labour. Thus the saving on the unloading and distribution of a cargo of 2,000 tons would in the aggregate represent about £200, after making full allowance for depreciation and running costs and taking proper credit for the saving in time that would result on the performance of work by machinery.

Conveyors for Goods Terminals

Mr. Bentham also dealt at some length with possible savings in the handling of railway traffic at freight terminals, and in Fig. 2, I reproduce

Receiving from this conveyor, a further set of conveyors (reversible) marked on the sketch "C," "D," "E," and "F," would run down the various platforms to carry the packages to the wagons. Men would be stationed at the junction between the circular conveyor and the conveyors running along the platforms at the points above indicated in order to divert the packages from the circular conveyor to the platform conveyors.

The circular-ended conveyor "B" should be run level with the floor at the "loading on" position, but should rise to a height of, say, 2 feet at the point where the traffic has to be diverted to the platforms conveyors. These conveyors would travel along the platforms at a height of 2 feet above floor level, the goods being transferred to the platform by means of portable chutes. The adoption of

while the other sketches give sections of elevations in different positions.

This, in brief, is an indication of the manner in which modern machinery developments are helping to cheapen the cost of transportation. It should always be borne well in mind that in all classes of transport it is the terminal costs that are the main item, and anything that will tend to reduce them should always receive careful consideration. But these appliances are not merely of service in connection with transport terminals. They are—in a modified form—admirably adapted for use in factories and large works, and in fact are being increasingly adopted in Great Britain. Their utility has been proved, and it is now only a matter of time before the major portion of heavy manual labour is dispensed with.

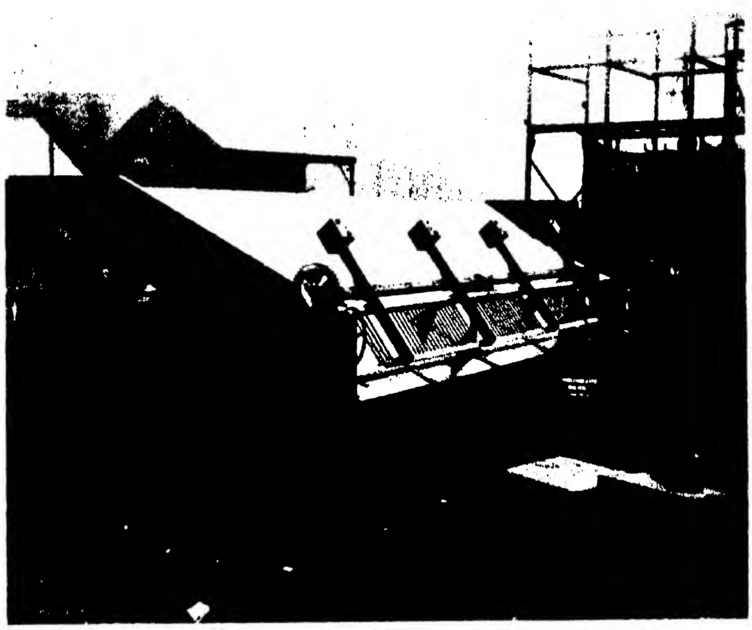
A New Coke Car

MESSRS. Stableford & Company Limited, of Coalville, Birmingham, who have a great reputation as builders of railway rolling stock, have recently supplied a large coke car for use in the plant of the Waleswood Coking Company, of Waleswood, near Sheffield. The vehicle, which is shown in the accompanying illustration, is of sound construction and measures 40 feet over headstocks, with an extreme width of 15 ft. 9 in., and height of 7 ft. 9 in. It is built to run on the standard gauge and designed to be manipulated by a winding engine and cable.

The red hot coke from the ovens is ejected on to the car floor and runs down to the gates. The vehicle is then drawn to and fro under jets of water, which quickly reduces the temperature. Thus the quenching of the coke is only a matter of a few minutes, and the vehicle, after standing about fifteen minutes longer for the contents to cool completely, is drawn to the loading dock and the coke transferred into waiting railway wagons for despatch to the consumer. The coke car is then available for removal to receive the discharge from other ovens.

The vehicle runs on six cast steel wheels, and is fitted with spring drawgear at each end, spring buffers of the usual railway wagon type being fixed at one end only. The under frame is built up of 12 in. × 3½ in. × ½ in. channels, tied together with angle and gusset plates, and the body is constructed of angles and plates all

(*Continued on page 229.*)



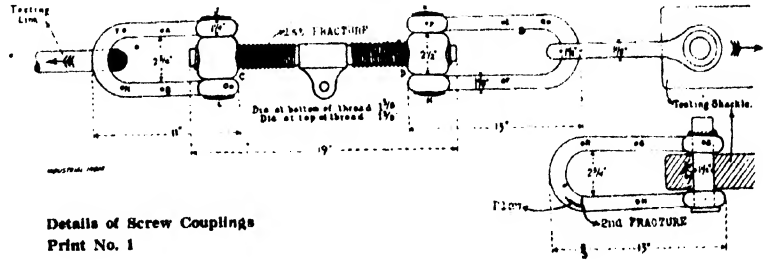
Large Coke Wagon — *Stableford & Co. Ltd.*

Nickel Chrome Steel for Railway Screw Couplings

A short article describing certain tests carried out on Nickel Chrome Steel Screw Couplings, manufactured by Cammell Laird & Company Limited.

IT is generally recognised that, as in flying, so also in steel manufacture, the recent War provided so peremptory a stimulus that the progress in both these arts during that period far surpassed anything likely to have accrued under the normal developments of peace-time.

While it is not, of course, always possible to adapt the knowledge thus acquired to peaceful purposes, full advantage has been taken of these developments in the manufacture and treatment of Nickel Chrome Steel, as applied to railway screw couplings—additional strength of which is of vital importance. Many years ago, the gradual increase in the weight of trains, and the capacity of wagons led certain companies, more particularly the Indian Railway Companies,



Details of Screw Couplings
Print No. 1

For METHOD OF TESTING and POSITIONS OF FRACTURES, see Print No. 1, attached.

Gauge points were marked on the coupling at AB, CD, EF, GH, JK, LM, NO, PQ, RS, and ST, and the movement of these points was noted as the load was gradually increased. After certain loads had been applied, the pressure was released, and any permanent set noted. After the screw had broken, the loose shackle was tested separately.

Test No.	Marks	Position of gauge points.		Movement and Set, in inches. Load in Tons. 1	18	30	35	40	50	60	70	80	85	Position of fracture.	Maximum Load. Tons.	Tons per sq. in. at bottom of thread.	Appearance of fracture.
		AB = 4"	Closing in	Zero	None	.02	.02	.03	.07	.09	.12	.19	.21				
			set	—	—	—	—	—	None	.03	.06	.11	.13				
	C. L. & Co. Ld.	CD = 12"	Extension	Zero	—	—	—	None	.02	.03	.03	.05	.05	1.			
			set	—	—	—	—	—	—	—	—	—	None				
	N.C. Steel B.N.R.	EF = 4"	Closing in	Zero	None	.03	.04	.06	.10	.12	.19	.26	.30				
			set	—	—	—	—	—	None	.03	.10	.20	.24				
	1491	GH = 4"	Closing in	Zero	.03	.06	.07	.10	.12	.16	.22	.31	.35	Screw	114 22	76.9	Fibrous with a silky edge.
			set	—	—	—	—	None	.02	.06	.12	.22	.27				
	1130 1922	JK = 15"	Opening out	Zero	.02	.03	.04	.05	.05	.08	.09	.11	.12				
			set	—	—	—	—	—	—	—	—	—	None				
P. 451	JMD	LM = 15"	Opening out	Zero	None	.02	.03	.03	.04	.06	.08	.10	.11				
			set	—	—	—	—	—	—	—	—	—	None				
	Q.R. 214	NO = 8"	Extension	Zero	—	—	—	None	.02	.03	.04	.06	.07				
			set	—	—	—	—	—	—	—	None	.02	.04	2			
	62 72 tons	PQ = 10"	Extension	Zero	—	—	—	None	.02	.02	.07	.10	.11				
			set	—	—	—	—	—	—	None	.03	.07	.08				
	Proved 35 tons	RS = 10"	Extension	Zero	—	—	—	None	.02	.03	.04	.07	.08	Loose Shackle GH	122 60	—	Ditto
			set	—	—	—	—	—	—	—	None	.04	.05				
		ST = 42"	Extension	Zero	.06	.11	.13	.17	.19	.25	.38	.52	.60				
			set	—	—	—	—	—	None	.05	.20	.28	.37				

to look for a substitute for Yorkshire Iron or Straight Carbon Steel, and this led to the eventual selection of Nickel Chrome Steel for these important components.

This was a class of steel widely used during the war, and considerable experience was then obtained as to the best heat treatment to ensure uniformity and perfect soundness. This experience was applied by Messrs. Cammell Laird & Company to railway screw couplings, and the result was highly satisfactory, as will be seen from the accompanying facsimile of a test sheet showing the results obtained at the Sheffield Testing Works, on a coupling manufactured by this firm—and one selected at random from a lot put forward for inspection. It may be mentioned that this test is quite typical of the tests obtained in connection with a contract for several thousand couplings, which Cammell Laird's are completing, and when it is added that, so far, not a single coupling has failed at test it will be evident that all doubts regarding the consistency of the steel may be set aside.

The test is, of course, a destruction test, the specified minimum load being 100 tons, and it is instructive to note that, in addition to being able to withstand this degree of tension, the nickel chrome coupling, apart from actual fracture, will carry about twice the tonnage of straight carbon steel couplings without permanent distortion. The elastic limit is 85 per cent. of the ultimate strength. The weight, by the way, is 10 lbs. less than the carbon steel couplings.

The risk of injury to the steel by overheating at any stage in the course of manufacture is reduced to a minimum in the method adopted by Messrs. Cammell Laird & Company Limited, as the essential operation of heat treatment is carried out under the most accurate and careful pyrometric control.

A leading British steel maker recently estimated that rust and other kinds of corrosion cost the world five hundred million pounds every year. The ravages of corrosion are so great that we are not surprised to learn that in Great Britain a proposal has arisen for the formation of an association of manufacturers of products which are non-corrodible and anti-corrosive.

The Electrification of English Main Line Railways

At a joint meeting of the Midland Branch of the Institution of Mechanical Engineers, with two of the Local Engineering Association, held early this year, the above subject was discussed, and the views of a number of prominent engineers were recorded. We give below some extracts from this very interesting discussion.

THE Chairman (Sir Henry Fowler), said that no time could be more opportune for discussion of this subject. If they could give a lead, although he was afraid this was impossible, as to what railways were likely to require for electric current, it would be most desirable. There were some few mechanical points to be dealt with. Mr. A. W. Gibbs, of the Pennsylvania Railroad, in a paper read before the Franklin Institute, had pointed out difficulties arising with low centre of gravity and symmetrical wheel-base. We might take it, that if we could neglect financial considerations, electrical and mechanical difficulties could be overcome. The financial difficulties were, however, great, and for lines of low density of trade traffic first cost and also maintenance cost were likely to be high for the work done.

Mr. H. N. Gresley (Locomotive Engineer, North Eastern Railway), observed that it was a subject which, of late, had been much to the fore as the electrification of railways had been strongly urged as a means of enabling railways to pay their way and reduce their working expenses. Unquestionably the electrification of subservice and suburban railways carrying a dense passenger traffic had achieved successful results. On a mineral section of the North Eastern Railway the goods results had been enhanced by the fact that the Company was saved the cost of providing a power station, a supply of cheap power being available. He suggested, however, that the problem of main line electrification was a totally different and much more difficult matter. It could not be urged that the main lines were congested. As a matter of fact, the train passenger mileage on the principal railways was only about 70 per cent. to 75 per cent. of what it was in 1913, while the goods mileage was 80 per cent. to 85 per cent. A much greater tonnage could therefore be carried with the existing equipment without any necessity for doubling the lines. In those circumstances it would not appear that a huge expenditure on the electrification of the railways would give a commensurate return, after paying the interest on the outlay. On the other hand, if the trade of the country improved to such an extent as to necessitate the doubling of the main lines and the provision of more locomotives, even then the question of the electrification of main lines would require very serious consideration. Such electrification was, of course, largely contingent upon the price at which current could be obtained, and that, in turn, was dependent upon the erection of the super-power station. The latter seemed to be linked up with the electrification of main line railways. During the past years several papers had been read on this subject; the comparisons, however, referrred principally to the cost of fuel and repairs, little mention being made of the cost of electrical equipment of the lines with substations, third rails, or overhead transmission. No mention was made, either of the extra cost of maintenance due to third rails, or overhead wires, and, in the former case, the extra cost of maintenance of the running track due to the presence of the third rail. In making comparisons the most modern steam locomotives should be compared with the most modern electric locomotives.

A very important paper on the Electrification of Railways was read by Sir Phillip Nash, in the early part of last year, and he (the speaker) might perhaps quote one or two points which had a very direct bearing on this subject. Broadly speaking, the electrification of main lines could only be expected to show direct savings where traffic was very dense, and even in such cases the most favourable conditions were a net-work of lines covering a limited area, or a section of line where the volume of traffic was such that increased line capacity must be provided if steam haulage was to continue.

It was stated recently, that the cost of electrifying a railway was something like £20,000 per mile, and that included the provision of a third rail, substations, and power station, also the electric locomotives. Those figures were for a very dense traffic, and were based on some twelve or fifteen years ago; it was suggested that probably they were double to-day, but he would take those figures as they stood. It has been stated recently, that the weekly receipts per mile on English railways was £106, which would give a yearly revenue of about £5,000 per mile. If it was going to cost £20,000 to electrify a mile of English railway, the interest of 5 per cent. per annum was £1,000 yearly. The receipts per mile to-day he was taking the whole of the railways, and was not referring to suburban lines were stated to be about £5,000 per mile; and if £1,000, or 20 per cent. of the earnings was to be absorbed in paying interest on the capital expenditure on electrification, it seemed to him to be somewhat difficult to make out a strong case.

He was strongly in favour of the electrification of suburban railways, and railways where it was necessary to spend a large amount of money in doubling lines. In those cases he thought it was very likely that the electrification could show a great advantage. For long lines of railways, with traffic which was not dense, it appeared to him that unless the cost of electric supply could be reduced very much below the present figure, there was not likely to be sufficient financial return for the money which would be involved in carrying out the scheme.

Mr. William Willox (formerly Chief Engineer of the Metropolitan Railway), said that since 1913, the price

of coal, the cost of materials of all kinds, and the rates of wages had mounted so high, and passenger and freight prices had been consequently so raised that the railways were losing traffic. Competition from road traction had arisen, and was as serious as competition from electric tramways and motor omnibuses. Gradually suburban railways were electrified at a considerable cost (mostly owing to each railway having to provide its own power station), and were successful. The Metropolitan Railway in 1913, carried nearly 122 million passengers, and 182 millions in 1919. The Lancashire and Yorkshire trebled their traffic. Sir W. Forbes of the London Brighton and South Coast Railway, stated quite recently that his electrified lines brought 150 per cent. more traffic and 200 per cent. more money, and showed on the capital expended a return of over 15 per cent. Now he wanted to electrify the main line to the coast towns. The East London Railway—in the electrifying of which he himself had a hand—was largely in tunnel and passed under the Thames in Brunel's tunnel. This line was electrified without interfering with the traffic. Up to 1913 it was worked by steam, and carried 5,506,664 passengers; after this the number of passengers steadily increased, and in 1920, the number was 16,307,382, an increase of 184 per cent. The London and South Western Railway electrification increased their traffic by 100 per cent. In 1915 the North Eastern Railway equipped their Shildon-Newport line, which with sidings was 50 miles long, with overhead electrical track equipment. This line dealt with heavy mineral traffic drawn by powerful electric locomotives, five of which did the work of thirteen steam locomotives. In America there were a number of cases where main line working had been and was being turned to electric working, with most favourable results, especially where there were heavy gradients and tunnels. In South Africa the railway from Glencoe Junction to Pietermaritzburg, 171 miles, was to be electrified.

Accommodation

Owing to the continuous increase of traffic into terminal stations the question of accommodation arose. This might be solved by costly extension of the terminus or by electrification. The Metropolitan Railway hauled its main line steam trains from 7 or 9 miles out by electric locomotives, and the same thing would have to precede main line electrification in many cases. The cost of the electrification on such railways as the Metropolitan, including power-house and everything was somewhere about £20,000 a mile pre-war cost. The cost of electrifying the East London Railway, which received current from Lots Road, was about £5,400 per mile pre-war. The power-houses were intended to be built near the coalfields where coal should be plentiful and cheap. There was no engineering difficulty in electrifying existing steam railways, even when the traffic was dense, with either the contact-rail sysetm or the overhead track equipment. No cases were known on the Metropolitan Railway, where men had been killed or injured if ordinary care were taken. The cost of ordinary maintenance of a rail-contact line was found to be £12.64 per mile per annum.

An efficient change-over

There were over 600 trains a day in and out of the main line part of Baker Street Station. The old station was pulled down and every line in the station was altered in position. A new station and new offices were built on columns over the lines and platforms, and no serious accident happened to any man and no train was delayed. On the West London line, electrification was carried out while the traffic was carried on regularly, and, with the added 2s. per week per man "juice" money, maintenance amounted to £13.1 per mile per annum. As to increase of staff only one gang of five men was added, and this was in the densest 9 miles of line. With power supplied for electrification, signalling could be electric or electro-pneumatic and track circuiting could be readily installed throughout, thus adding additional safeguards, and the sections might be lengthened or shortened in order to accommodate more trains.

Mr. Roger T. Smith (Chief Electrical Engineer, Great Western Railway), said that although experience of main line electric locomotives was very limited in this country, there was enough to interpret the much longer foreign experience in terms of British railway working. Some of the advantages of electric over steam locomotives were beyond dispute. An electric locomotive used power transmitted to it from outside; a steam locomotive was an independent unit, with power limited by its maximum boiler out-put. An electric locomotive should be built to haul the heaviest train of wagons, which the draw-gear would stand, but one of the great limitations of electric traction in this country was that 700,000 wagons were owned by private owners, and that the draw-gear was not kept to the strength which the railway companies themselves maintained.

Within any of the fifty British Railway structure gauges, electric locomotives could be built to haul the heaviest train which would be wanted in this country. He referred to trains of about 1,500 tons. For most of the structure gauges the heaviest steam locomotive that could be built had already been provided; but even if the maximum size of steam locomotive had not already been reached on most of the railways, the heaviest locomotive axle load, which could be carried by bridges, had been reached in the steam locomotive. The axle-loads of electric locomotives were materially less, partly because there was no boiler, but also because they could make all the axles, if they liked, power axles. Although on the Continent, and to some extent in America, designs for electric locomotives were used in which the rotary motion required by the wheels was obtained from the rotary motion of the electric motors through connecting-rods and coupling-rods, such designs seemed to be unnecessary in Great Britain. Reciprocating parts were impossible to balance completely, and expensive to maintain, and therefore one should avoid them; and where the rotary motions of the wheels of an electric locomotive were obtained from the rotary motion of the electric motors through gearing, the balancing could be as nearly perfect as possible, and the first cost of the electric locomotive was a minimum. The maintenance costs on the Newport and Shildon electrified lines of the North Eastern Railway were a quarter of those of the corresponding steam locomotives which preceded electric locomotives; and on the Chicago, Milwaukee, and St. Paul Railway they were one fifth. More labour was entailed in starting and putting away a steam locomotive than was the case with an electric one, and at stated intervals the locomotive had to stop to take in

coal and, it might be, to stop to take in water. If in repair, an electric locomotive was ready to haul a train when the driver stepped aboard.

Pooling was difficult with a steam locomotive, whereas the electric locomotive could be used for at least twenty out of the twenty-four hours every day with pooling, and, in some cases, it had been used for twenty-three out of the twenty-four hours. The haulage results of this, and of other advantages which he had not time to mention, was that whereas each steam passenger locomotive could haul from 20,000 to 25,000 train-miles per annum, according to traffic conditions, an electric locomotive could handle from 40,000 to 50,000 train-miles; and that while a steam goods locomotive could haul from 10,000 to 15,000 train-miles per annum, also according to traffic conditions, an electric locomotive could easily double this record. On the Newport and Shildon line of the North Eastern Railway, which was a mineral line, the electric locomotive train-miles were just double the steam locomotive train-miles. On the Norfolk and Western Railway in the United States, where coal trains of over 3,000 tons were formerly hauled by twenty-seven steam locomotives in one division, similar mineral trains were now hauled by seven electric locomotives. The ratio of average speed to maximum speed was greater with the electric than with the steam locomotive. An electric locomotive having a maximum speed of 60 miles per hour could generally maintain an average speed 50 per cent. greater than the speed of the corresponding steam locomotive.

As to the saving in cost power by using electric locomotives, instead of steam locomotives, careful comparison on the Chicago, Milwaukee, and St. Paul Railway, showed that 6½ lb. of coal in a steam locomotive, in 1915, was required to do the same work as one kilowatt of electricity in an electric locomotive in 1916. Generally speaking, coal costs were now in this country something like 50 per cent. of the total works costs of kilowatts delivered to the track; and if the coal (including hauling, carriage, and all the expenses of handling ashes and their disposal), as actually delivered to the furnaces of a generating station cost now 30s. per ton—which would correspond to 20s. per ton at the pithead—this represented 0.16d. per 1 lb., and the works costs to the railway on the above basis would be 0.60d. delivered to the track. The above American experience showed—assuming the same quality of coal—that the equivalent power in the steam locomotive would be 1d., leaving 0.4d. to pay for the interest on the new capital.

Contest of Portable Gas Generators

The recent French trials for Gas Producer Vehicles have revealed some very interesting results, and we reproduce in this article some of the leading facts of these trials, and also some details of Messrs. John J. Thornycroft's Gas Producer, which was awarded the highest marks.

THE jury of the contest of Portable Gas Generators, at their meeting at the Automobile Club of France, announced as follows the classification of the competing firms, after an examination which continued during two weeks of the result obtained in the course of the test:—

1.—The firm of Thornycroft, which equipped with a Gas Generator of their manufacture a lorry specially constructed for that purpose.
2.—Societe Industrielle de Vierzon, Delaugere Lorry, Orleans.
3.—Maison Lion Hermite, of Lyon, Saurer Lorry.
4.—Societe Industrielle de Vierzon, Scemia Lorry.

A slight accident which happened to the Gas Generator of the apparatus fitted on the Saurer Lorry by the Societe Le Gaz Pauvre dans ses Applications (G.P.A.), which obliged this vehicle to run the last kilometre of the track on petrol, did not allow the jury to classify this apparatus, in accordance with the terms of the contest, in spite of the very appreciable qualities which it showed, as will be seen by the detailed report of the tests which we reproduce. These tests were twofold: Bench tests concerning the regularity of working, the economy of consumption, and the purity of the gas, which took place in Bellevue at the mechanical laboratory of the Research Department, on the 26th and 27th June last; and road tests including two runs of 60 kilometres, which were carried out on the 21st and 22nd July, at an average speed of 15 kilometres 250.

Characteristics of the Apparatus concerned and results obtained.

All the motors which participated in the contest were four cylinder motors. Their characteristics were as follow:—

The Bench test lasted three hours at full charge, two hours in watching, a quarter of an hour when empty, one hour and a half at half charge, one quarter of an hour at one quarter charge, and three hours at three quarters charge, and the apparatus showed the following results:—

	Bore	Stroke
Thornycroft	114·3	152·2
Societe de Vierzon -		
Delaugere	100	140
Seemiq	125	140
G.P.A.	110	140
Lion Hermite	110	140
Cazes	100	150

The following results were shown in the running tests :–

—	H P.	Consumption
Thornycroft	24 2	59kg. 25 (charcoal)
Vierzon Delangère	15.45	46kg. 4 (1·5 charcoal, 4,5 wood)
Vierzon Scemia	20 6	63kg. 6 ,, ,,
G.P A.	16 2	41kg. 9 (charcoal)
Lion Hermite...	15.8	42kg. 3 (charcoal)
Cazes	20.4	40kg. (charcoal)

	Gross tonnage carried.		Empty	Ton-kilometres.		Con-sumption.	
	Day 1.	Day 2		Day 1.	Day 2.	Day 1.	Day 2
						kg.	kg.
Thornycroft ...	7,460	7,429	4,250	200	216	53.2	51
Delangère	7,568	6,886	3,610	250	208	86	80
Vierzon Scemia ...	8,347	7,977	4,695	236	213	81	88
G.P.A.	7,470	7,476	3,820	227	227	54	46
Lion Hermite ...	7,650	7,644	4,093	215	220	56	51
Cazes	7,944	7,945	4,422	219	219	54.5	46

Now that the result has been obtained, the question may be put whether the success will only be one to satisfy curiosity, or whether the contest just concluded marks a first practical step towards the adaptation of a fuel so far not used to motor locomotion. Does it mean a new field for the utilisation of producer-gas ?

Mr. Auclair, the President of the Committee of Mechanics at the Research and Inventions Department, was asked for his opinion, and he replied with a very clear and most impartial statement which reflects mathematically the results obtained, and is only a judicious interpretation, without in any way favouring hypothetical speculation.

"In the first place," he says, "a reduction of power must be expected when passing from petrol to producer-gas. However, in order to calculate this reduction, it is essential not to lose sight of the adjustment. According to whether the comparison applies to a petrol motor, with a first-class adjustment, or with a moderate adjustment, the results will be very different. If the power of the petrol motor is represented by the unit, that of the motor driven by producer-gas will vary in the first case between 0.05 and 9.73, whilst in the second case it will reach 0.70-0.90.

"Consequently whenever one is dealing with a lorry having a motor liberally dimensioned, as in the case of an Omnibus, producer-gas can without difficulty replace petrol. On the other hand, a lorry with an exact motor, equipped with a gas Generator, will have the greatest possible chance of not running.

"Coming to the question of the difficulties, there is nothing special to be said about the starting and driving. On the other hand, the upkeep is a matter to be considered, because with producer gas it must be expected that the mechanism has to be cleaned more frequently than with petrol, perhaps every fortnight. Finally, will not the carbon deposits and resulting ashes mean a more rapid wearing out of the parts? This is a point which cannot be settled at present. Experience alone will show how the motors driven with producer-gas are in condition after long use.

"With respect to the economy to be expected from the system, it arises from a double arithmetical operation. On the one part one must consider a reduction of running, a diminution of the transport capacity, which will result in an increase of the amortisation and working expenses, which increase may be expressed on an average, as is shown from the preceding, by the co-efficient 1.4. On the other hand the use of producer-gas will considerably reduce the price of the fuel in the relation of 10 to 1. In fact the consumption per H.P. hour is half a litre of petrol for the petrol motor, 7,000 grammes of charcoal for the producer-gas motor. If petrol is calculated at Francs 1.80 per litre and charcoal at 120 Francs per ton, the cost of the H.P. hour is Francs 0.90 in the first case, and Francs 0.084 in the second case.

"If it is admitted that the consumption of fuel is to be considered as to one half when establishing the expenses of a lorry (although this is not a principle generally admitted), the balance sheet of the operation will finally be for one half on the basis of a diminution in the relation of 10 to 1, that is to say 0.5 by 0.1-0.05, for the other half on the basis of an increase in the relation of 1 to 1.4, that is to say 0.5 by 1.4-0.70, so that consequently the value of the unit with petrol will be 0.75 when using producer-gas, which in the end means a saving of 25 per cent."

This is a rather interesting result to encourage the efforts in this direction.

It is stated that the use of producer-gas is perfectly compatible with the use of petrol, and the two systems can without inconvenience be employed at the same time on the same lorry, whilst the regularisation of the running can be obtained by the successive and judicious use of the one and the other. The starting, the application of the brake, the climbing of difficult parts call for the use of petrol, whilst the arrivals and light declivities call for producer-gas.

In that case the lorries with exact motors can also benefit of the advantages of the use of a cheaper fuel.

In short, the results of this first contest are highly encouraging.

The initiative taken by the Research and Inventions Department will be very fruitful, because it will induce the industry to make a fresh contribution to the solution of the vital problem of fuel economy.

General Description of Thornycroft Suction Gas Producer for M. Vehicles

As long ago as the year 1905, Messrs. Thornycroft carried out exhaustive experiments with producer gas, and fitted out quite a number of vessels and motor launches with suction gas producers, using anthracite, coke, wood refuse, etc., as fuel.

In the Motor Boat Reliability Trials, held in August, 1905, a motor launch was run which had most economical results, and was awarded a gold medal.

As a result of sixteen years' experience, a portable suction gas producer has been evolved for use on commercial vehicles, and quite a number are being turned out by the firm's Basingstoke works, in response to orders and enquiries from the Colonies, and also from other parts of the world where natural fuels, such as charcoal, for instance, can be cheaply obtained on the spot.

The chassis to which the gas producer is fitted is the War Office type chassis, of which some thousands were supplied to the British Government for service during the war.

The engine is a standard petrol engine, 4-cylinder, 114 m/m bore by 152 m/m stroke, with the exception of the compression ratio, which is raised for running on gas.

From the drawing of the vehicle, it will be seen that every part of the producer plant is easily accessible, and that it in no way interferes with the fitting of an ordinary body or cab.

Care has been taken in the design to ensure that all manholes and cleaning doors are easily removable by means of dogs or of fly-nuts, to obviate the use of spanners.

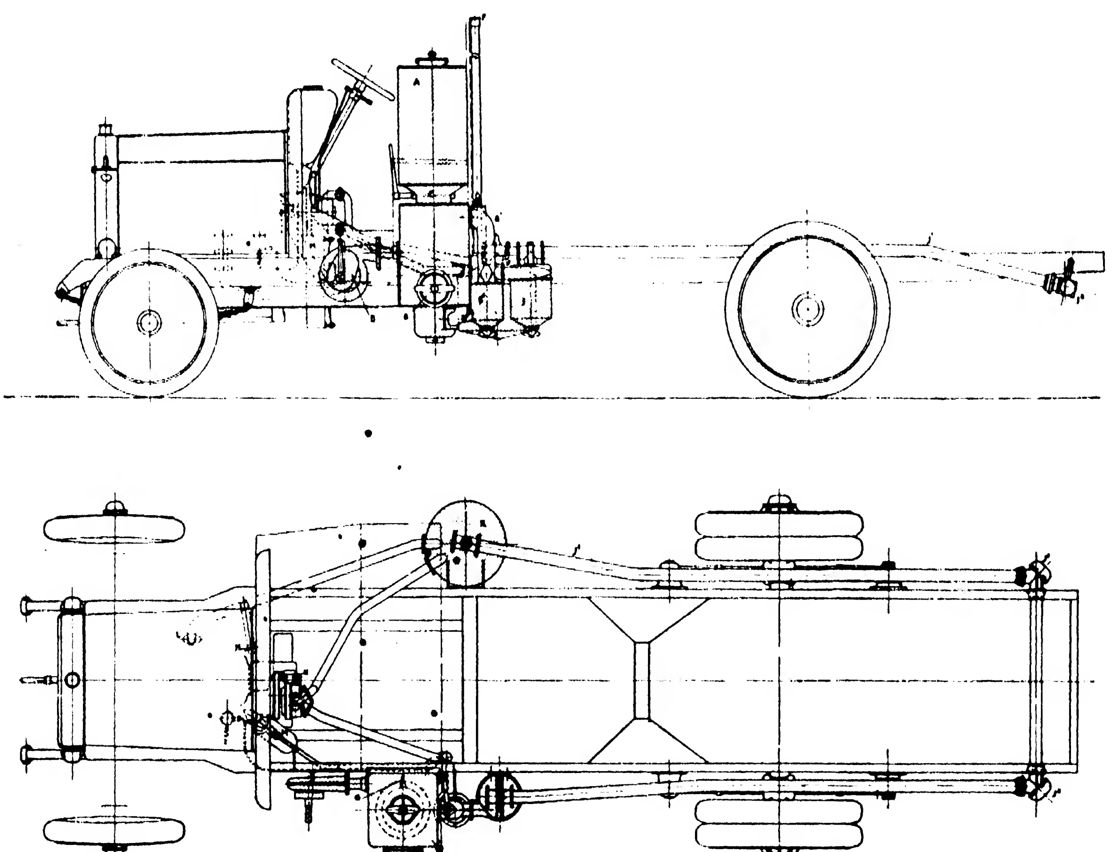
The producer itself is a brick or corundum lined cylinder inside a square casing, which, in addition to lagging the cylinder, forms a jacket for heating the air before it passes into the ash pan, and so into the fire box.

The door marked B on the producer enables the fire to be easily laid, and also acts as a clinkering door.

The hopper A is made of the same section as the producer, to facilitate fitting on the chassis, but the height is adjusted according to the nature of the fuel used.

The valve between the hopper and the producer already mentioned is marked C on the drawing.

The hot gases from the producer pass down through the water-jacketed pipe B1, which terminates in a plain



Details of Thornycroft Plant

dust collector, B2. This removes the larger of the dust particles which come over with the gas. This water-cooled pipe, in addition to cooling the gases, generates a certain amount of steam, which is passed into the ash pan. From this pipe the gases pass into the cyclone dust separator J, which takes out the smaller particles of dust, and the gas is then passed round the chassis through the cooling pipes J1, which are arranged with cleaning doors (J2) at the corners, so that all the pipes can be cleaned.

This cooling pipe leads into the dry scrubber K, which is packed with wood-wool, or horsehair, or similar cleaning material, which finally cleans the gas before it passes to the inlet pipe of the engine marked L.

The steam generated by the hot gases in the water-jacketed pipe B1 is not nearly sufficient for the satisfactory running of the producer. The variable quantity of steam required is generated in a boiler fitted on the exhaust pipe of the engine marked M, this boiler being easily removed without dismantling the exhaust manifold or any part of the producer, and is itself easily dismantled for cleaning.

The hand blower, for starting up, marked D, is accommodated under the footboard and on the driver's step, and is, therefore, in a very handy position for operating.

The exhauster, which is used for keeping the fire in proper condition when the engine is running light, is marked N, this exhauster being vertically over the fly-wheel and carried from the engine itself, and not from any part of the chassis. It is easily operated by a lever within handy reach of the driver.

The outlet from the producer, through which the gases are blown in starting up, and also when the exhauster is in operation, is shown at F, the height of this pipe being sufficient to take it above the cab, so that the gases are at once clear of the driver and above any other ordinary traffic which may be encountered.

The starting up of the plant from cold is a simple operation, usually completed under ten minutes, and requires no particular skill, and the handling of the vehicle on the road is as simple as that of a petrol vehicle. The attention required by the plant itself depends naturally to a large extent upon the nature of the fuel used. If the fuel is dirty or dusty, the dust extractor and scrubber will require attention more often than with cleaner fuel, but to clean the dust extractor it is only necessary to remove the doors at the bottom by slacking back large fly-nuts, and in the case of the scrubber, since the inside can be entirely removed by taking off one fly-nut, the re-packing of this with suitable straining material is almost as simple an operation. No water is used in the cleaning or scrubbing of the gases, with the result that corrosion of parts due to chemical or electrolytic action is obviated, and the cleaning operation is simplified.

The Thornycroft producer plant differs from other plants on the market in one or two essential features, as the direct result of our extensive experience already referred to.

The steam is generated in a separate generator (not attached to the producer at all) by the heat of the exhaust gases from the engine itself.

The heat of the exhaust gases must necessarily be in proportion to the power developed by the engine, according to its load, thus the correct amount of steam for the producer can be provided under all conditions.

The steam generator can be taken entirely to pieces for cleaning by detaching it from the engine. In portable plants this is of very great importance, owing to the fact that whenever hard or brackish water is used, a scaly deposit will be formed on the inside of any steam generator in a very short time, seriously interfering with the efficient evaporation of the water.

Whilst other makes of gas producers can be fitted to the Thornycroft type "J" vehicle, it is obvious that the Thornycroft producer plant, being primarily intended and designed to be used in conjunction with Thornycroft vehicles, is, therefore, an integral part of the chassis, and is not added as an auxiliary, as the other plants are, consequently the weight is cut down to a minimum. Also, there are no mechanical movements, which, if they went wrong, would put the plant entirely out of use.

One of the difficulties encountered in the running of gas producer vehicles is the immediate provision of a sufficient quantity of proper quality gas on opening up an engine after the vehicle has been standing for a time, say in a traffic block in a city, or making a delivery of goods. With the Thornycroft plant, special arrangements are made which are the subjects of patents to overcome this difficulty, which also occurs in a lesser degree when the vehicle is working on very light loads, or when over-running when going down hill. This arrangement overcomes the necessity to continually race the engine when working at other than full power, in order that the gas making process may be continuous.

The plant will work efficiently with good clean anthracite of the size known as peas, or with charcoal, but in the case of light and bulky fuels, such as the latter, a somewhat larger hopper is fitted. This, however, is not important, as a valve is fitted between the hopper and the producer, as will be seen by reference to the drawing, and this valve can be shut off whilst the producer is in operation, and the hopper refilled at any time, without interfering in any way with the fire.

With the Thornycroft plant all petrol is dispensed with. The plant is started by means of a hand blower, and the engine can be started up on gas in ten minutes, after which the vehicle can be left standing with the engine running slowly for an indefinite period, with the certainty that it can get away with full load or no load immediately the throttle is opened.

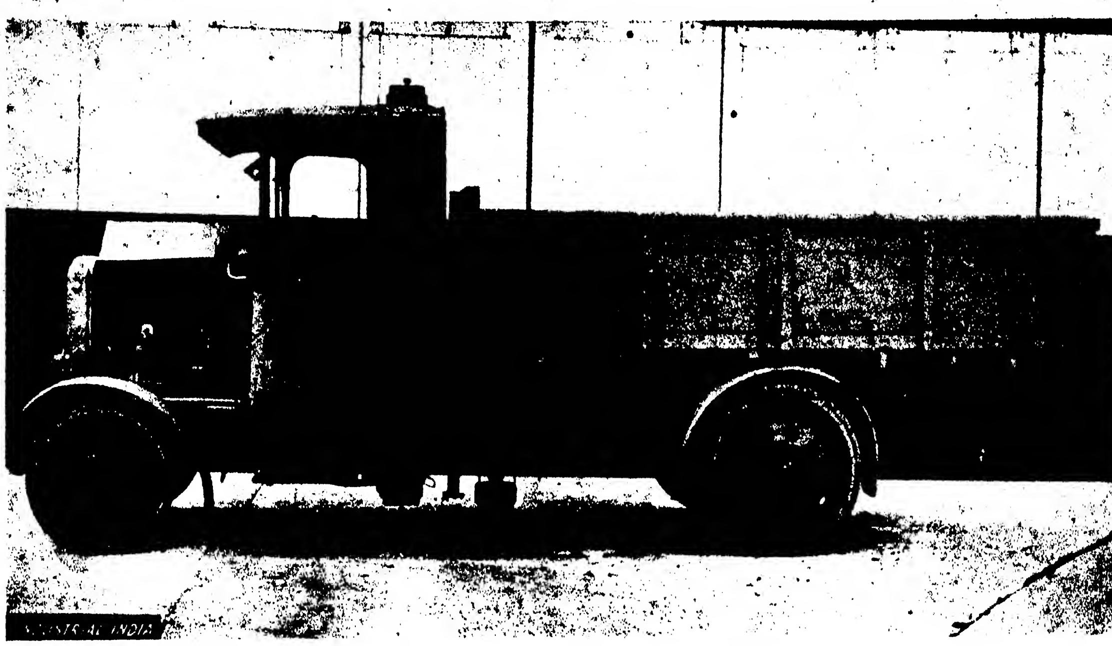
As regards performance on the road, the following table shows the comparative results obtained with charcoal and anthracite as fuel on a 28-mile course. These may be taken as quite average figures, as a log of one of the service vehicles at the Thornycroft works running on anthracite, doing long and short journeys, country and town traffic, over a distance of 1,579 miles, used 2.6 lb. of anthracite per mile.

The anthracite used is not any specially selected grade, although obviously the cleaner the anthracite and the smaller the percentage of ash in its composition, the better the results will be in service. The anthracite we use is the same quality as used in our stationary gas producers at our Basingstoke works.

COMPARATIVE ROAD TESTS OF ANTHRACITE AND CHARCOAL.

Distance	28 miles	28 miles
Time ...	2 hrs. 20mins.	2 hrs. 20 mins.
Miles per hour	12	13 4
Fuel ...	Anthracite	Charcoal
Lbs. per mile	2.51	2.9
Water used	45 lbs.	35 lbs.
Gross weight	7 tons 10 cwts. 2 qrs.	7 tons 9 cwts. 2 qrs.
Condition of road	Dry	Dry
Weather	Fine	Fine
Date of test	6/4/22	26/4/22.

The immense saving in fuel cost of anthracite over petrol can b



General view of Thornycroft Lorry and Gas Producer

deduced from these figures. With anthracite at 63/- a ton, the cost is about ¾d. per vehicle mile. Taking the consumption of petrol as 7 miles to the gallon, this would work out at one-quarter of the fuel cost of petrol.

From the point of view of the Colonies and foreign countries, where petrol is expensive, if not unobtainable, there are immense possibilities for this plant, as the nature of the fuel which can be used in the producer is not limited to anthracite or charcoal, but any carbonaceous matter which is at present worthless, may, with certain alterations to the plant, be turned into useful fuel.

Experiments are continually proceeding in connection with fuels, and the problem of running on maize, which was put up by one of the Colonies, although it proved somewhat troublesome at the outset, we understand has been completely solved.

Improving Railway Communication in New Zealand

The Southern Alps of New Zealand have long offered an effective obstacle to the fullest development of trade and commerce, but as, by the end of the present year, it is hoped that the electrified railway through Arthur's Pass Tunnel—the longest in the Empire—this obstacle will have been removed by the ingenuity and skill of the engineer. The construction of a tunnel under the Alps was sanctioned in 1902, but it was not until 1908, that headings were commenced. The headings met on July 20th, 1918, ten years after the commencement of the work, and since then the construction of the permanent way and the installation of the electrical equipment has been in hand. The length of the tunnel is 5 miles, 545 yards, and the line is perfectly straight, with a uniform grade of 1 in 33. The approach roads to the tunnel have presented as much difficulty as the tunnel itself, and on one side in a length of 9 miles there are 17 other tunnels, the longest 2,000 ft., besides three high steel viaducts, one of which carries the rails 236 feet above the gorge. The total cost of the work is little short of one million pounds, but as it will enormously aid settlement and industry by bringing mines and lumber lands nearer to their markets, there can be little doubt that it has been money well spent, and a work that speaks well for the enterprise of the New Zealand Railway administration.

A New Coke Car

(*Continued from page* 221.)

securely riveted together. The floor is of substantial construction, this being essential owing to the fact that the coke is ejected from the ovens in practically a solid mass. The floor, therefore, is composed of ⅝ in. steel plates, lap jointed and secured in the framework by ⅞ in. countersunk rivets.

As will be noted from the illustration, the gates are operated by large hand wheels, driving on worm and gear wheels, and fitted with heavy counterweights to facilitate rapid opening. Altogether, the vehicle is a good example of well-designed construction for the specific duties for which it is intended. It also has the advantage of economising labour to the fullest extent in being more or less self-tipping.

SCIENCE

Conducted by A. H. HAVER, M.I.N.A. & K. S. DICKINSON, F.C.S.

THIS SECTION DEALS WITH THE APPLICATION OF SCIENCE TO INDUSTRY AND PARTICULARLY DEALS WITH APPLIED CHEMISTRY

The Colloidal State (ii)

(*Continued from page* 171.)

EVEN when a colloid has separated out from solution in the solid form, it can, in many cases, be brought back into colloidal solution again, or be "Peptised," as it is said, by small quantities of various substances. A very interesting illustration of this behaviour, and one which is of the greatest importance in our everyday life, is seen in the plastic properties of clay. Clay is a hydrated silicate of alumina which possesses the property, in its normal condition, of forming, more or less readily, with water, a fine suspension or suspensoid colloid. On this property depends what is called the plasticity of clay, and just as the presence of certain substances renders the clay suspension more stable, so also certain substances facilitate the passage of the precipitated clay into the state of colloidal suspension; they render the clay more plastic.

Everyone is familiar with the story of how Pharaoh commanded his taskmasters to increase the burdens laid on the Israelites by withholding from them straw wherewith to make bricks; and doubtless many have wondered wherein the hardship lay. By most people, probably, the view has been held that the straw was added as a binding material, much as hair is used in mortar; but such an explanation is scarcely satisfying when it is remembered that the straw fibre is a very weak one, and when we read, moreover, that when straw could not be obtained, stubble was used. Another explanation may therefore be offered.

A Brick Clay Example

About fourteen years ago it was found by Dr. E. G. Acheson, to whom we owe the discovery of carborundum and the process of making artificial graphite, that when clay is mixed with a dilute solution of tannin, it becomes much more plastic, and the strength of the dried brick is moreover, greatly increased. Although straw does not contain tannin, it was found that when straw is treated with water, the extract obtained has the same action on clay as tannin has, the plasticity of the clay and the hardness of the brick being greatly increased. It seems, therefore, a plausible view that the straw was used, not for the purpose of binding the clay, but for the purpose of rendering the clay more plastic; and the particular burden imposed on the Israelites would therefore consist in their having to make bricks with a less plastic and, consequently, more difficultly worked material. In allusion to this Dr. Acheson gave to the clay which had been rendered more plastic by the addition of tannis, the name of "Egyptianised clay."

The property of tannin of facilitating the production of an ultra-microscopic or colloidal suspension, has also been applied to the production of a colloidal suspension of graphite for use as a lubricant. By means of the very high temperature which can be obtained in the electric furnace, Dr. Acheson was able to prepare from anthracite coal a form of graphite which could be ground to a fine powder. Such graphite, however, when shaken with water or oil, yields a suspension from which the graphite soon settles out; but if the graphite is first treated with a solution of tannin, it becomes "deflocculated," as it was said, and forms a colloidal suspension which can be kept indefinitely without showing any tendency to separate out. The colloidal suspension of "Deflocculated Acheson Graphite," in water is known as Aquadag, or water-dag, and is used as a lubricant for metal-cutting tools. By filtering the aquadag under pressure through thin films of rubber, the colloidal graphite can be obtained as a paste. When this is mixed with oil, a colloidal suspension known as oildag is obtained which is much more efficient as a lubricant than oil alone.

These colloidal suspensions of graphite are so fine that the graphite particles will pass through the finest filter paper. On adding salts, however, the graphite is flocculated, as we have seen is the case with colloilad suspensions of sulphide of arsenic and of clay, and the graphite is now retained by filter paper, and separates as a sediment on standing.

Different Classes of Colloid

Although we have seen that various differences exist in the nature and behaviour of the two classes of colloidal solutions, the emulsoid and the suspensoid, there is one respect in which the two classes resemble each other, namely, in the relatively large extent of surface exposed by a given amount of colloid. This large development of surface is due, in the one case, to the honey-comb or sponge-like structure of the colloid sol; and, in the other case, to the minute size of the particles, for the more a given mass of matter is subdivided, the greater becomes the extent of surface exposed. To the existence of this highly developed surface, one of the most characteristic and important actions of colloids, namely, the removal of substances from solution, is due. When, for example, a colloidal solution of ferric hydroxide, the so-called dialysed iron of the pharmacist, is shaken with a dilute solution of

white arsenic, a large proportion, it may be practically the whole, of the arsenic is removed from solution and collected or absorbed on the surface of the colloid, and it is to this property of colloids that the use of dialysed iron as an antidote in arsenical poisoning is due.

This absorbing action of a large surface depends on the fact that the concentration of a dissolved substance in the surface layer of a solution is different from, and frequently greater than, what it is in the body of the solution. When the concentration of the dissolved substance in the boundary layer is greater than in the body of the solution, the dissolved substance becomes concentrated in the layer of solution in contact with the solid, and this film of concentrated solution remains adhering to the surface of the solid when the rest of the liquid is poured off. Herein we find, also, the explanation of the action of the very porous material, charcoal, in removing dissolved colouring matter from solution, a property which finds a very important application for the removal of the colour from molasses in sugar refining.

But the special and peculiar behaviour of colloids depends not only on their power of surface absorption, but also on the fact that the colloid particles are electrically charged. In some cases, *e.g.*, ferric hydroxide and aluminium hydroxide, the colloid is positively charged, but not in most cases, it is negatively charged.

Colloids Electrically Charged

The existence of such an electric charge can readily be demonstrated with a colloidal solution of sulphide of arsenic. If this is placed in a U-shaped tube, and if we then insert in the liquid wires connected with the terminals of a high voltage battery, or dynamo (the ordinary electric lighting circuit can conveniently be employed), one in either limb of the tube, we shall find that the sulphide of arsenic migrates towards and collects around the positive terminal. The particles of arsenic sulphide, therefore, carry a negative charge of electricity. Even with fine suspensions, such as suspension of fine clay, or a slime of peat, the same phenomenon is observed; the clay particles or the peat fibres collect around the positive firm mass. Since the effect depends primarily on the voltage of the current, while only an insignificant amount of electricity is used, this process of cataphoresis, or electric transport of suspended particles, constitutes a very economical means of freeing a fine suspension of slime from water; and it has, in fact, found industrial application in Germany to the partial drying of very wet peat or peat slime. The high cost of fuel required to evaporate off the water from such very wet peat is thereby saved, so that it becomes possible to utilise peat-bogs which are so wet that they could not otherwise be worked with commercial success.

When a positively charged and a negatively charged colloid, such as ferric hydroxide and arsenic sulphide are brought together, the oppositely charged particles attract one another, and this leads to a mutual flocculation and precipitation of the colloids.

The property of absorbing and removing substances from solution which colloids possess in virtue of the large surface which they expose, together with the fact that the colloids are electrically charged, plays an important part in the processes of dyeing, in agriculture, in the purification of water and of sewage, in the life processes of animals, and plants, and in many other domains.

The process of dyeing is by no means a simple one, and no single explanation can be given of the way in which dyes are, in all cases, fixed on the fibre of the material dyed. But in recent years the general advance in our knowledge of the peculiar behaviour of the substances on the colloidal state, has led to the recognition of the important role which colloids may play in the dyeing process. Not only are the fibres of silk, wool, and cotton similar, in many respects, to colloids, more especially in possessing a structure exhibiting a largely developed surface, but many of the dye-stuffs are also colloids. In some cases the dye may be fixed on the fibre by the addition of salts, the colloidal dye being thereby precipitated in the fibre just as addition of salts produces a precipitation of colloidal sulphide of arsenic. But in other cases the process of dyeing is probably one which depends largely on a mutual precipitation of colloids having opposite electric charges, the negatively charged fibres attracting and fixing on themselves positively charged dye-stuffs.

Whilst it is found that, in very many cases, silk and wool have the power of taking up and fixing the dye-stuff directly, it is frequently found that in the case of cotton the fixation of the dye has to be assisted by a mordant, which is either a colloid itself, or can give rise to a colloid. The colloid so formed is deposited on and within the fibre to be dyed, and attracts and fixes oppositely charged colloidal dyes. According to the nature of the dye, so must be the nature of the mordant employed, salts of aluminium, chromium, etc., which give rise to the hydroxides of the metals, being used when the dye has a negative charge or has acid properties (*e.g.* alizarin): while tannic acid and similar substances are employed for dyes with a positive charge, or with basic properties. Chemical actions, however, also play an important part in the dyeing processes.

Agriculture

In agriculture, also, the colloidal state is of the greatest importance. In the soil there exist various colloidal substances, such as the humus, colloidal ferric hydroxide and aluminium hydroxide, clay, etc. Owing to the pressure of these, soluable substances, such as the salts of potassium, phosphates, and other substances necessary for the life of the plant, are absorbed and retained in the soil, and so kept available for the support and nourishment of vegetation, instead of being washed away into the rivers and sea. The humus, moreover, being a colloid similar to albumin and gelatin, has the property of imbibing water and so helps to maintain the soil in a moist condition, while it also acts as a substrate for the bacteria concerned in the conversion of nitrogenous organic matter into such a form as can be taken up by the plants, as well as for the other bacteria always present in the soil.

Owing to the presence of such colloids as ferric hydroxide and aluminium hydroxide, filtration through soil acts as a very efficient means of purifying sewage and other waste water, from organic impurities. These impurities in sewage, for example, have been found to be, to a large extent, negatively charged colloids which are therefore precipitated and retained by the positively charged colloids, ferric hydroxide and aluminium hydroxide. By such filtration through the soil, therefore, even the highly impure water which drains from cultivated and manured land is rendered comparatively sweet and harmless. In

the same way, the purification of drinking water by filtration through beds of sand or through charcoal, depends on the removal of impurities by absorption on the large filtering surface exposed, and on the retention of positively charged colloidal matter, bacteria, etc., by the negatively charged sand or charcoal particles.

An important application of the behaviour just described, is found in sewage farms, where the drainage of towns is pumped on the land and the liquid allowed to drain through the porous soil. Here, the waste organic matter is retained and affords a rich nutriment for the growing crops, while the liquid effluent which drains away is such that it might be drunk with safety. By such means can, in suitable surroundings, a source of annoyance and loss be turned to profit.

Modern Theories

Although, in recent years, the importance of the colloidal state in its bearing on many of the activities of daily life, has become more clearly recognised and more fully appreciated, it is in connection with our conceptions of the constitution of matter that the investigations of microscopic and ultra-microscopic suspensions have gained some of their most brilliant triumphs. For more than two thousand years there has existed in men's minds the idea of matter as made up of separate, discrete particles, and in the nineteenth century, as we have seen, this idea was given a more definite form at the hands of Dalton and of Avogadro. But the particles, the molecules, which make up matter as our eyes reveal it to us, are not in a state of rest. In the case of gas, these molecules are in a state of almost inconceivable tumult and commotion, which even the restraint imposed by the condensation and the congealing of the gas to the liquid and the solid state, it is not able wholly to subdue. Such, at least, is the picture of matter which the genius of a Clerk Maxwell and a Clausius revealed to us in what is known as the kinetic theory of matter. But although this theory has been found to give a satisfactory explanation of the behaviour, more especially of gases, and has enabled one to calculate not only the size of the molecules (roughly, one hundred millionth of an inch in diameter), but also the speed of their flight, there were not wanting some who refused to believe in the objective reality of molecules, and of the picture presented by the kinetic theory. And yet, even as early as 1827, these molecules, although by their minute size removed far beyond the range of human vision, had, all unknown to their observers, made their presence manifest by their actions. In that year, the botanist Robert Brown, while examining suspensions of pollen grains under the microscope, observed that the particles were never at rest, but were in rapid motion, vibrating, rotating, moving irregularly along a zig-zag path, sinking, rising—perpetually in motion. In this Brownian movement, as it is called, the full significance of which has only recently been grasped—it had, indeed, been observed long ago by the French naturalist, Buffon, who saw it in a manifestation of life—we have an actual picture of that tumult and commotion of the molecules which were revealed to the mental vision of mathematical physicists. But it is not, of course, the motions of the molecules themselves that we see in the Brownian movement, but only the effect of the incessant bombardment of the coarser, visible particles of the suspension, by the molecules of the liquid.

Over a lengthened period of time, the number of blows which a suspended particle of sufficient size, say such as is visible to the naked eye, would receive from the molecules of the liquid in which it is suspended, would be the same in the different directions. The suspended particle, therefore, would show no sign of motion. But if we imagine the period of time made sufficiently short, the number of impacts of the liquid molecules will no longer be equal in different directions, the impacts will no longer balance one another, and if the suspended particle is small enough, it will, at each blow, be caused to move, first in one direction and then in another, and all the faster the smaller the particle; and it is this motion of a particle of a suspension under the blows which are rained upon it by the molecules of the liquid, that constitutes the Brownian movement. With particles of ultra-microscopic dimensions the phenomenon is exhibited with extraordinary vividness, and it is to this Brownian movement that the stability of colloidal suspensions is largely due. From the careful quantitative investigations of this phenomenon which have been carried out in recent years, the various molecular magnitudes—the kinetic energy of the particles and their velocity of diffusion, for example—have been computed; and such is the closeness of agreement between the results so obtained and the values which the kinetic theory would lead us to expect, that we cannot any longer hesitate to believe that in the rapid, darting motions of the ultra-microscopic particles we have made manifest to us something of the turbulent stir and bustle which is going on unceasingly in that underworld of molecules which lies beyond the reach of our sense.

Methods of Remuneration

(*Continued from page* 214.)

satisfactory, which have been introduced chiefly to cover specific industries. These systems include the Rowan, Emerson, and Gautt plans.

It is obvious that for men engaged on work of a more or less repetitive character, the system of guaranteeing a minimum time wage, with a standard product, and a piece rate for output in excess of the standard, is very fair, and conduces towards good output. It is only fair, however, to see that the standard output is within the capacity of the average worker, otherwise there is no incentive to increase production. In such a system the "trier" is protected by the minimum wage, while the best workers receive increased remuneration for extra efforts put forward. It is sometimes advisable, in the interests of the firm, to penalise for spoiled work where it is directly traceable to the man himself; otherwise men will rush their work for the sake of the extra pay. It must be made absolutely certain, however, that the spoiled part is the fault of the worker himself, and not faulty material, and only an efficient system of inter-operation inspection can determine this.

Some time ago surface indications of the presence of manganese ore were detected in Scotland; and in order to test the extent of the formation a trial shaft was sunk. This revealed a seam of manganese ore seven feet thick. Samples of this ore were examined and found to contain from 45 per cent. to 65 per cent. of the metal.

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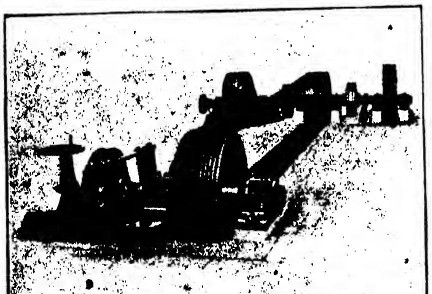

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Reviews

JOURNAL OF INDIAN INDUSTRIES AND LABOUR.

In the February number of the JOURNAL OF INDIAN INDUSTRIES AND LABOUR, Messrs. E. R. Watson and K. C. Mukerjee of the Technological Institute at Cawnpore, discussed the nature and extent of the deposits of Reh salts in the United Provinces, and estimated that a very large quantity of carbonate of soda existed in the soil covering a large portion of that province. In the current number of the Journal the same authors deal with the problem of utilizing these Reh salts in an article in which they give the results of various experiments conducted by them with the object of ascertaining the best method of preparing pure soda ash, caustic soda, sodium sulphide and other products from this indigenous material. The results of these researches and the account of the methods by which they were obtained will be of much interest to industrial chemists.

On the occasion of His Royal Highness the Prince of Wales' visit to Calcutta in December, 1921, the work of decorating the streets along which the Royal procession was to pass was entrusted by the Government of Bengal to the Government School of Art at Calcutta. The way in which this commission was executed is briefly described in a very interesting article in the Journal by Mr. Percy Brown, the Principal of the School, who describes how the ornate columns, which decorated the roads were constructed of papier mache placed over a wooden framework. The results fully justified the experiment and constituted an achievement of which the Calcutta School of Art may well be proud. The article is well illustrated with plates showing the students of the School of Art at work on the preparation of the papier mache models, and the painting of the decorations, while a view of some of the pylons in position gives an excellent idea of the beauty and appearance of solidity which can be achieved by the employment of this medium.

The Journal contains a detailed account from the pen of Mr. B. M. Das, Superintendent of the Calcutta Research Tannery, on up-to-date tanning processes under Indian conditions. The value of the work done by Mr. Das in the interests of the tanning trade is well known, and in the present article the whole subject is treated in a most complete and practical manner.

Mr. D. Penman, Principal of the School of Mines and Geology, which is about to come into existence at Dhanbad, in Bihar, and Orissa, contributes an article on Mining and Geological Education in India. After touching on the need for technical education to keep pace with the industrial advancement of a country, he shows how important a part is played by technical education in the case of mining. The article gives a brief history of previous attempts to enlarge and raise the standard of mining education in India, with particular reference to the coalfields of Bengal and Bihar and Orissa, and explains the need for adequate facilities for mining and geological education. The demand for trained mining engineers and geologists with a knowledge of mining cannot be adequately or satisfactorily supplied from outside the country, and the importance of the projected School of Mining and Geology can hardly be over-estimated.

Mr. E. E. A. Cove, Inspector of Industrial Schools in the Central Provinces, makes an appeal for the adoption of industrial careers involving an acquistion of practical knowledge by the upper and middle classes in India. The country needs more producers, and her industries demand that the best brains in the country should be brought to bear on them. Mr. Cove argues, with reason, that Indian capital will be shy of Indian industrial ventures until it is assured that such ventures are in the hands of practical men, whose ability and status will inspire confidence.

Mr. S. R. Khosla, Dyeing Expert to the Government of the Punjab, writes on vegetable dye-stuffs, and gives a brief account of the processes of extraction and utilization of vegetable dyes with a brief description of the difficulties met with in the industries. Possible methods of utilizing the waste products of liquor distilleries in India are discussed by Mr. F. E. Bharucha, Assistant Director of Industries in the Bombay Presidency.

WIRE ROPES

We have before us an English Copy of the New (8th Edition), General Catalogue of Messrs. George Cradock & Co. Ltd., Wakefield, just issued by this well-known firm of rope experts.

The publication of a General Catalogue by a Company of so long an experience and standing as Messrs. Cradock --whose Catalogue has always been regarded as of the highest authority in the Wire Rope Industry - must be of enormous value, and will doubtless receive a very warm welcome from all those concerned in the purchase, maintenance and usage of Wire Ropes.

In addition to the fullest details of the many ropes made by the firm, a seperate section is provided dealing with these modern and rapid methods for the transit of light and heavy goods. Excellent views and descriptive matter are given of some of the installations carried out by the Company in India, Java, and elsewhere in connection with plantation, irrigation and other work, which should have special interest for Tea Planters and Companies engaged in the growth of tropical produce.

It is difficult to realise the time and labour involved in the lay-out and production of a work of this nature, but the amount of detail and illustrative matter, together with the exceptionally fine tables of rope sizes, weights and breaking strains is such that is very rarely met with.

The whole production reflects much credit on the firm, and is a catalogue they may well be proud of. We have ascertained that in addition to the English Edition, which is now available, there will shortly follow the French and Spanish copies.

INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

Volume II DECEMBER, 1922 Number 5

The Future Management of Indian Railways

The question as to whether the Government of India or private companies should operate the Railways is one still causing controversy, and the information given in this article, together with the views on the general question, should therefore be of interest

AT the opening of the Legislative Sessions, in September, the Viceroy of India, Lord Reading, was able, in his speech, to report certain important decisions that had been taken with regard to railways, following the recommendations of the Acworth Committee. He referred to the setting aside of Rs. 150 Crores during the next five years in connection with railway rehabilitation, the appointment of a Central Advisory Board—constituted on somewhat different lines from those advocated by the Acworth Committee,—the proposed early formation of a Rates Tribunal, and the reorganisation of the Railway Board. In view of the wide difference of opinion, he was, however, unable to give any indication as to the policy of the Government with regard to railway operation in the future, but it is evident that definite decisions will soon have to be made, as the Government contract with the East Indian Railway expires in December, 1924, and with the Great Indian Peninsula Railway in July, 1925.

During the past few months the Government of India has sought the advice of those engaged in commerce and industry, and it is well that they have done so; for, after all, it is the public who have to pay the piper, and they should at least have an opportunity of taking part in the melody. The position is somewhat complicated by the fact that the Indian Central Railway Advisory Board is reported to have decided by seven votes to four in favour of State railway management as against company management, while the reply of that powerful body, the Bengal Chamber of Commerce, is unanimously opposed to State management.

Briefly stated, the Bengal Chamber of Commerce reiterates its previously expressed opposition to State management, for the reasons that this has proved financially unsound in other countries, railway working is adversely affected by political influences, and that under State management there is a lack of initiative and flexibility.

The document addressed by the Government to the Bengal Chamber of Commerce is a lengthy one, and refers at the beginning to four possible methods of management, as discussed by the Acworth Committee and tabulated below:—

(1) Management by English companies;

(2) Management by a combination of English and Indian companies;

(3) Management by Indian companies; and

(4) Management directly by the State.

The first two methods were unanimously rejected by the Committee, which, however, was equally divided on the alternative between management by Indian companies and direct State management.

The major question on which views were invited was as to whether the East Indian and Great Indian Peninsula Railways should, on the expiration of their contracts, be taken over by the State or entrusted to a company domiciled in India, while secondary, but still important, questions were as follows:—

(*a*) In the event of company management, what is the preferable scheme of administration to be adopted?

(*b*) In the event of State management, should a board of directors be associated with the agent, and in that case should the board be composed mainly or entirely of business men?

Two schemes of company management were included in the Government document, these having been prepared "as a basis for discussion."

Summary of Bengal Chamber's Reply

In their reply, the Bengal Chamber of Commerce explain that they have considered the question with particular reference to the East Indian Railway, and that while many of the considerations governing their conclusions would have similar application to the Great Indian Peninsula Railway, it does not necessarily follow that they should.

With regard to the main question, that of State *versus* company management, the Chamber states that the Government is aware that the Chamber has always been opposed to a policy of general State management, and that it is still "unhesitatingly of the same opinion." They therefore desire most strongly to see the East Indian Railway continue under company management. In pointing out that they have given the question further, and very mature consideration, the Chamber reminds the Government that, as indicated in a previous communication, they have had the great advantage of experience of the working both of State-managed and of company-managed lines, and as far back as 1916 they gave it as their considered opinion that the public were better served by the company-managed lines than by the State lines.

The Chamber add that the arguments against State management are well brought out by the five members of the Acworth Committee who favour company management. "An important and weighty section of opinion, including that of the Railway Board, is," they point out in para. 254 of their report, "opposed to the view that State management is the best, holding that, as railways are primarily commercial undertakings, they should be managed on a commercial basis, so as to secure economy and efficiency, that is to say, by a company with a board of directors. They also referred to many references in the Acworth Committee's report to the experience of countries where State management exists all of which went to prove that State management of railways was wholly bad.

In particular they referred to the railways of Switzerland, of Austria, and of Italy, while with regard to American experience of State management, they mentioned specifically the remarks of President Harding, who, in a recent address to Congress, referred to the heedlessness of cost of Government operation, and "emphatically asserted that there would be a foundation for rebuilding (the railway industry) if it was clearly understood that there would be no State ownership."

The Chamber also repudiates the suggestion, in connection with company-managed lines, that the State, by far the largest shareholder, depute their rights to a company having only a small stake in it. They especially note in this connection that it is erroneous to talk of "deputing rights," and in justification for this statement, observe that at several points in their report the Acworth Committee call attention to "the constant interference of the Government in the details of railway executive management."

In dealing further with this question, it is important to remember that the recommendation of a part of the Acworth Committee as to State management must be read "as coupled with and conditioned on, the adoption of the recommendations made with respect to financial and administrative matters." Yet, while the proposals of the Railway Finance Committee as to capital expenditure have been accepted, there still remains the question as to whether the railways shall have a separate budget of their own, and assume the responsibilities for earning and expending their own income. Under date December 16, 1921, the Railway Finance Committee state that under existing conditions it is not possible to separate railway finance from general finance. This question is inextricably woven with the general question of State management, and the two must be considered together. As those members of the Acworth Committee who supported direct State management made their recommendations conditional on the arrangement of a separate railway budget, the refusal to do the latter may be held to vitiate their views on the former.

Subsequently, the Chamber discussed the two schemes submitted by the Government, and definitely turned down the idea of a system of railway management on the lines of a Port Trust in connection with State operation. The two schemes submitted are considered at great length, and the final conclusions of the Chamber are as follows:—

(*a*) So far at any rate as the East Indian Railway is concerned, the Chamber are of opinion that, on the expiry of the present contract, the management should be entrusted to a company domiciled in India with a directorate not less than half of which should be Indian.

(*b*) The Chamber consider that scheme No. 1 forwarded with your letter provides the basis for a workable and satisfactory arrangement.

(*c*) In the event of State management being favoured, the Chamber are of opinion that any scheme of associating a board of directors with the Agent, on the lines of Port Trust management, should not be contemplated.

State or Company Management

While there are, of course, certain reasons peculiar to India that make the question of State *versus* company management rather more difficult to solve there than in many other countries, it should not be difficult to prove that many advantages attach to company management as compared with direct State operation. As Sir Sam Fay, General Manager, Great Central Railway of England, well said in his recent presidential address to the Institute of Transport, it should be capable of demonstration that *controlled* private management is better than *uncontrolled* State management. That, really, is the crux of the matter. State management is, broadly speaking, uncontrolled, in the sense that there is no authority to exercise higher control, and the door is consequently opened to considerable abuse. With company management, adequately controlled, there should result the highest efficiency, while the public has always the knowledge that their interests are being watched by the State.

This question of State *versus* company management of railways is a world-wide one. Only a short time ago, both in Germany and Switzerland, there was an insistent demand for the denationalisation of the railways, in order to check the many abuses and to ensure more effective management. The problem, too, has been deliberated in Great Britain, and it is an open secret that when Sir Eric Geddes set up his "grandiose" Ministry of Transport, it was with the definite idea of taking over the whole of the British railways, "lock, stock and barrel." In fact, the future intention of the Government to take over the railways had been foreshadowed by a Minister of the Crown in a speech to his Scottish constituents. But time went on, and it became increasingly apparent that the British public had had enough of State control, not only of railways, but of many other things. So the policy was changed, and the ultimate result was the passing of the Railways Act, 1921, under which the whole of

(*Continued on page* 238.)

INDUSTRIES

Conducted by FRANK DAWSON.

THIS SECTION DEALS WITH THE GREAT BASIC INDUSTRIES OF INDIA. IN THE PRESENT ISSUE WE DEAL PARTICULARLY WITH SUGAR

The Eastern Oilfields

BY SYDNEY H. NORTH, ASSOC. INST. P.T.

THE next few years will witness a considerable change in the oil situation from a producing point of view. The evidence on which this statement is based is clear and unmistakeable, and it will interest readers of this journal to traverse the main points in the argument. The United States are still the dominating factor in the world's oil industry, and are likely to remain so for some years. A limit, however, has been set to their fields' productivity by American geologists, and oil men, and this limit is marked as from 20 to 30 years hence. The wells will, of course, not become suddenly exhausted, but during the period allocated will gradually tail off, and probably remain productive for many years, but the relative importance of the output will be considerably depreciated. A glance at the following figures will convey an idea of the position of America in respect to production, and show the percentage progress between the years dealt with.

	Barrels (1 = 1,000 barrels.)	Percentage increase.
1916	300,767	
1917	335,315.6	11
1918	355,927.7	6
1919	377,719	6
1920	443,402	17
1921	469,639	7

From these figures one might conclude that the forecast made as to the decline of the American fields is not justified, but production has to be taken in conjunction with consumption to appreciate the exact position. A statement has been drawn up by an American authority which shows that the *per capita* production of crude oil in the States in 1900 amounted to 35.13 gallons, and that this had increased to 197.25 gallons per head of population in 1921. In 1918 the output of gasoline from the refineries of the United States amounted to slightly over 3½ thousand million gallons, while in 1921 the figure was over 5 thousand million gallons, an increase of 50 per cent. Another side-light is thrown on this aspect by the growth of the use of motor cars in the States, compared with the crude oil output. This is shown in the following figures:

	No. of Cars.	P.C. Inc. on prev. year.	P.C. Inc. in production.
1918	6,146,617	23	6
1919	7,558,848	23	6
1920	9,211,295	22	17
1921	9,500,000	5	7

The most important indication, however, is revealed in the figures showing the rapid increase in the imports of petroleum and its products, chiefly Mexican, into America. The quantities of oils brought in from outside have increased very extensively every year, and more especially since 1918, as is shown in the following statement: (1 = 1,000 gallons).

	Crude	Benzine.	Other refined.
1917	1,034,590.8	10,804.9	33,425.2
1918	1,347,543	11,560.9	45,144.6
1919	1,930,725	10,374.8	37,851
1920	4,459,362	40,478	69,500.9
1921	5,262,887	37,816	108,185

An analogous case to this movement in connection with the oil industry of America would be found in the importation of coal into this country, and certainly indicates an increasing disproportion between home production and home requirements, either for internal consumption or exportation.

This, then, is the position of the largest oil-producing country at the present time, and its study is essential to the true consideration of the general problem.

Now, apart from America in the West, we have Mexico, and the oil-fields of the South American Republics, none of which last are sufficiently developed to affect the world's supply. Mexico, therefore, remains the one great hope of the West, and there are in that country something like a hundred thousand square miles of land asserted to be petroliferous, which still remain to be developed. The next few years will prove what the new and unexploited areas in Mexico are worth.

Oilfields of the Orient

The chief centre of interest, however, in oil has now been diverted to the other side of the world, and the Orient is fascinating oil men as it has always fascinated archæologists and ethnologists. Persia, Mesopotamia, and the countries closely contiguous to these, are at the present time in the toils of political influences, not to be wondered at when one has gained a little knowledge in regard to their assumed potentialities as great future oil producers. It is, of course, always dangerous to prophesy on the extent and richness of oil land, the drill being the sole arbiter between barren and productive areas, but judging by the indications already given of Southern Persia alone, and by the investigations which, over a long series of years have been made in Mesopotamia, one is induced to think that the centre of gravity of the world's oil supply will, in the course of some years, be shifted from the West to the East. There undoubtedly exists a vast line of oil deposits stretching from the Dutch East Indies to Burma, through India, Baluchistan, Persia, Mesopotamia, and continuing westwards.

The principal source of oil in the first named is, of course, Borneo,

where the Shell Company obtained exploitation rights over an area of between 500 and 600 square miles, and as only a small proportion of this has been proved and worked, it is probable that there exist extensive and prolific deposits still undeveloped. The present producing area shows no signs of decline, and from 1917 these fields record a continuous increase in output. There are several oil horizons, from each of which a considerable supply is obtainable, and the wells now in yield tap deeper strata than they did in the early years. The figures of production for the years 1917 to 1921 are as under:

	Barrels.
1917	12,928,955
1918	13,284,936
1919	16,878,429
1920	17,529,210
1921	18,000,000

The three important producing areas in Borneo are the Koetei area; the Tarakan area, situated on the island of Tarakan, on the east coast; and the Miri area, on the west coast, in Sarawak.

The Koetei fields* are developed particularly along the very well-defined Sanga Sanga anticline. This anticline runs from north of the Mahakam to a point north of Balik Papan, the crest extending 100 km., and is divided into two separate domes, the northern being the Sanga Sanga Moera dome with the Sanga Sanga Moera oil-field, and the southern the Sambodja dome, bearing the oil-field of the same name. There is a depression in the anticline between these two domes, in the region of the Dondang River.

The older Miocene strata which underlie the upper Koetei delta series are not exposed on this anticline, but do crop out on the Palarang anticline, which runs parallel further inland.

The Koetei Fields

In the Koetei fields three distinct types of crude oil are found, viz., heavy asphalt oils in the upper strata, light asphalt oils at greater depths, and paraffin wax oils at still greater depths.

The structure of the Tarakan field is that of a system of two domes with a depression in between, the major axes of which run in N.-S. direction. In this area, which is also of delta formation, Pliocene sand dominates. The field is developed in part of the delta which was nearer the coast, and where, consequently, sands predominate, the interlying clays being not so well marked. Pliocene coals, or rather, lignites, often containing boulders of older coal from the Miocene formation, are frequent. The oil from this field is markedly uniform in composition.

The Miri field lies on the west coast of Borneo. The geological structure here is not yet so well known as that of the two fields described above. There is a well-marked anticline, the eastern wing being very much the steeper. The oil is drawn from the western wing. The strata here are also of Miocene age, and coals are conspicuous by their absence.

Productive Capacity

The oils of the Miri field are fairly uniform in character, but differ fundamentally from those of the Koetei and Tarakan fields.

What the aggregate productive capacity of these fields is, it is impossible to say, as information in this connection is difficult to secure, but that there are vast stores of oil still to be recovered from the oil lands of Borneo there can be little doubt. The wells are of quite a different description to those of Mexico, where enormous initial and subsequent outputs are obtained, and in some respects the operator prefers wells of this character to the high pressure wells of the west. They are easier to handle, less costly to drill, and the possibility of heavy loss from incapability of control, as well as from fire risks, are markedly diminished.

The oil-fields of Java and Sumatra are not to be compared with those of Borneo from the productive point of view, and cannot be considered as influential factors in the world's requirements. The output of Sumatra is more extensive than that of Java, though the average figure for the last five years was not as high as that for the preceding five years. In regard to Java, the reverse was the case. The production of the latter in 1920 was 312,000 tons, and of Sumatra 496,400 tons.

Before passing on to the consideration of the country which is destined to play the predominant part in Eastern oil supplies, namely, Persia, it will be interesting to refer to the possibilities of India proper and Baluchistan. Up to the present time British India has not figured in the list of producing oil areas of the Empire, although a number of concessions have been taken up and examined. This is rather incomprehensible in the face of the statements made by the geologists of the Indian Geological Survey, who testify to the fact that indications in various parts, especially in the North-West Provinces and the Punjaub, favour deposits of oil on a commercial scale. For instance, in the Suliman range the formation is stated to be similar to that running through the entire north of Persia, and reappears near the shores of the Caspian Sea, forming one of the most constant of geological occurrences in connection with oil deposits. In close proximity to Sherani is the district of Moghul Kot. From this place, down to Parwara, the rocks show a heavy dip, varying from N.N.E. to E, and between Parwara and the plains below there is a well-defined anticlinal, the crest of which lies at Dwamandi.

(*To be continued.*)

*James Kewley, Vol. VII, No. 27, Trans. Inst. P.T.

THE FUTURE MANAGEMENT OF INDIAN RAILWAYS

(*Continued from page* 236.)

the British railways, with few exceptions, are to be merged into four large groups by June, 1923, at latest. In effect, this will enable the companies to secure the economies to be gained from a consolidation of their resources, and at the same time leave sufficient competition to satisfy the public and ensure adequate service.

As I have previously intimated, it is my intention shortly to contribute a special article dealing with the Grouping of British Railways, so there is no need at the moment to deal further with it, except to add that India might well take a lesson from the experience of Great Britain, America, and many Continental countries, and think long and well before going out for direct State railway management, which has all the vices and few of the virtues of *controlled* company management.

The electrical operation of railway signals has already been adopted to a considerable extent at crowded junctions and other places where the traffic is dense.

Sugar Machinery (ii)

(*Continued from page* 190)

Following our introductory article in the previous issue of "Industrial India," we give below the first article dealing with the machinery used in a modern sugar mill. All the machinery illustrated in this article is manufactured by the well-known firm of sugar plant manufacturers, Messrs. Harvey Engineering Co. Ltd., of Glasgow, to whom we are indebted for the loan of blocks and drawings, and also for the data from which this article has been compiled.

IN describing the above firm's sugar machinery for a complete mill, we will follow the progress of the process through the mill from the arrival of the raw material. Two distinct processes are here described. The first is a brief description of the carbonatation process, and the second deals with the sulphitation process, but it will be noted that the latter stages of each process are exactly similar.

The sugar canes are brought in from the cane fields to the factory by railway or bullock carts, and loaded to the cane carrier which feeds the mill (Fig. 1), where the juice is expressed, passing through a multiple set of grinding rollers. The crushed cane or megass is conveyed to the furnaces for raising steam in the boilers, and in a well-balanced factory no outside fuel other than the crushed megass is required. The expressed juice from the mills containing the impurities of the cane is first of all treated with milk of lime, and goes direct to the first carbonatation tanks (Fig. 2). This, after being treated with carbonic acid gas and heat, which precipitates the impurities, is passed through filter presses (Fig. 3), where the solid impurities are separated from the juice. The purer juice is now passed to the second carbonatation tanks also (Fig. 2), and undergoes a similar process of treatment, and passes then to the second filter presses of similar construction to the first presses above described, but fewer in number.

The clear juice at this stage is now passed direct to the triple or quadruple effet evaporator, where 75% of its volume is evaporated under vacuo at a low temperature, thus preventing discolouring of the juice. Fig. 4 shows an arrangement of a quadruple effet evaporator, with its condenser, dry slide valve air pump, torricellian column supporting condenser, and all necessary fittings for a complete unit for evaporating the water as above noted from the clarified sugar cane juice.

The Evaporator

Fig. 5 shows in section the special features of the firm's evaporator.

The advantages claimed for the Harvey evaporating apparatus are, complete and rapid circulation of the juice, combined with proper distribution of the steam in the most effective manner for the heating of the juice; this is arrived at by the proper proportion of the various vapour pipes connecting the vessels, also in the

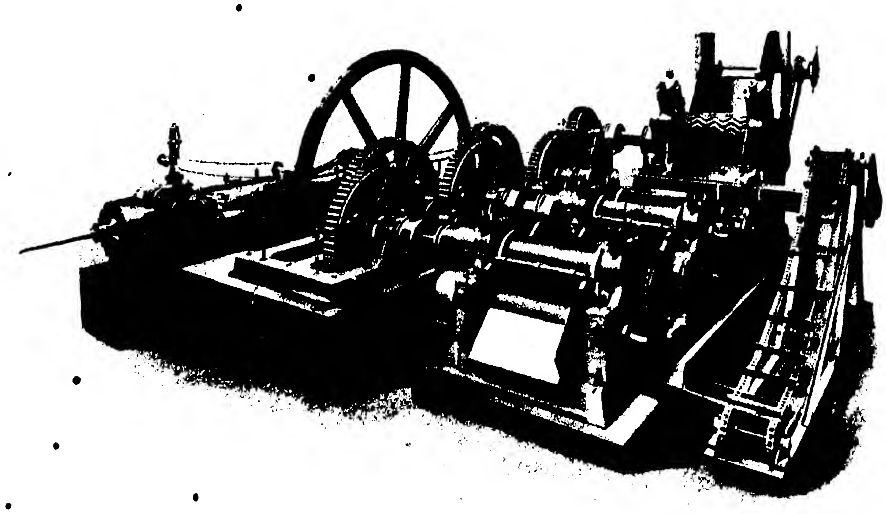


Fig. 1. Eleven-roller Cane Crushing Plant

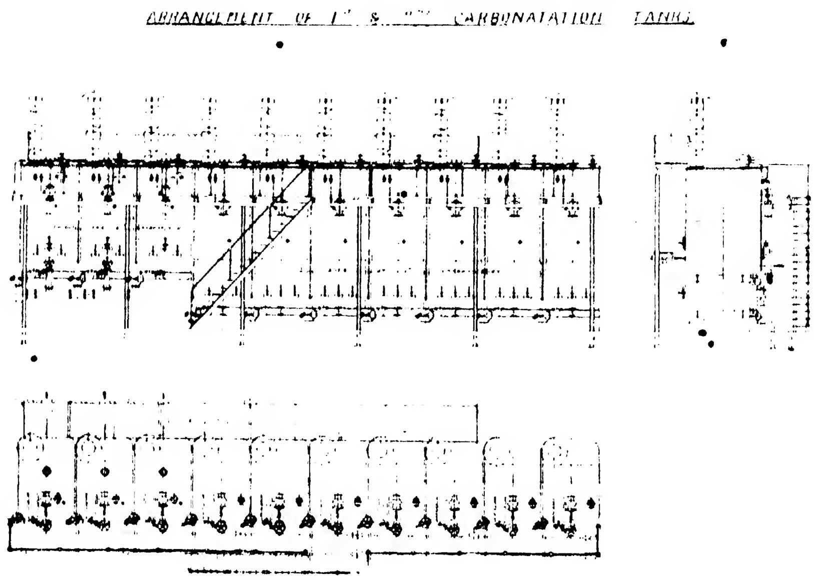


Fig. 2

form and position of the vapour inlets to calandrias. The main feature of the evaporator is two extra wide openings, one at the top and one at the bottom of calandria, for the free admission of the vapour, combined with a division plate across the inside of the calandria, whereby a high velocity is obtained in the circulation, consequently giving a rapid rate of evaporation, and at the same time scouring the tubes and keeping them clean. The vacuum pumps are of large capacity. Calandrias are drained by special improved pumps, and by an arrangement of connections which are automatic and positive in their action, no trap being required, except for the first vessel, whereby the calandrias are kept entirely free of all water. There is a special arrangement of pipes and cocks connected to main condenser, by means of which gases of any density lodging in any part of the calandrias are immediately drawn off; the accumulation of such gases being one of the sources of interruption to the free distribution and circulation of the vapour or steam in the calandrias. The usual back pressure, or exhaust steam, of 5 lb. per square inch, is ample to work the apparatus, which is automatic in its action, and owing to its extreme simplicity and moderate price, has given great satisfaction to sugar planters in all parts of the cane-growing world, reducing the cost of labour and effecting a very great

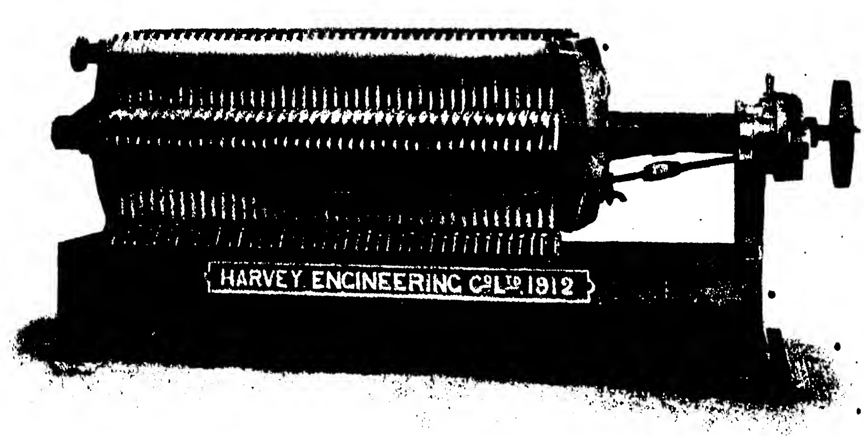


Fig. 3 42-Chamber Side Feed Filter Press

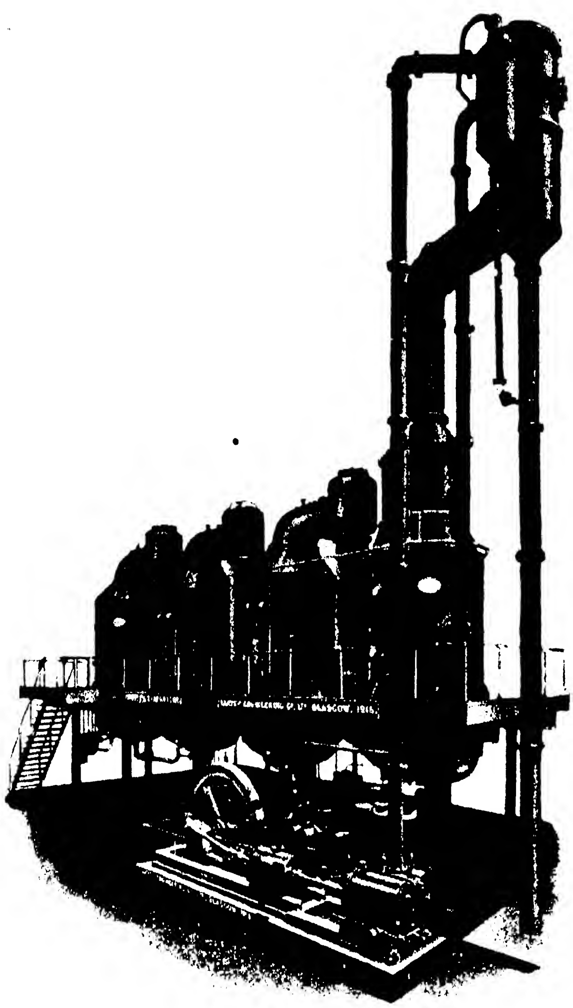
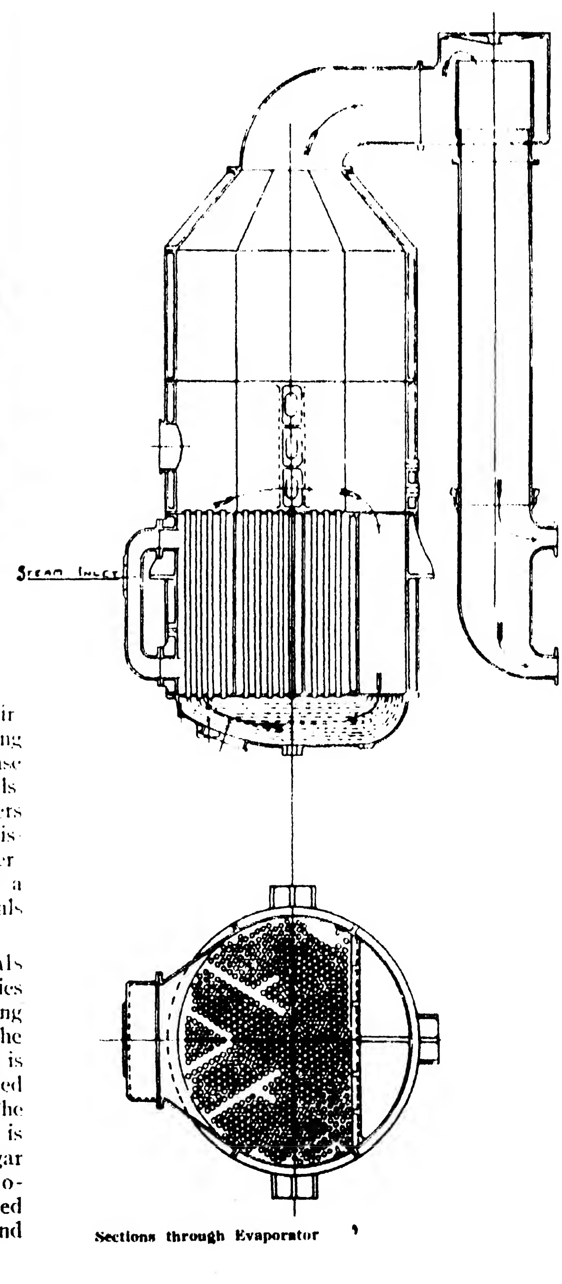


Fig. 4. Evaporator

saving in fuel. This evaporator is well known in all cane sugar countries, and is now at work in over 165 different sugar estates, and, we understand, giving every satisfaction.

The concentrated syrup from the evaporator is treated with sulphurous acid gas to further improve its colour, and then passes to the vacuum pans (Fig. 6). The syrup is boiled under vacuo here also, and increased in density until crystals commence to form, and are built up under the careful handling of the operator, who has to be specially trained in this operation, until the crystals have formed to the size required. The pan is then struck or emptied, the contents of the pan falling by gravity into crystallizers underneath (Fig. 7). The massecuite is kept in gentle movement by stirrers, the object being to further increase the size of the crystals From the crystallizers the massecuite is discharged into the over head mixer of a range of centrifugals (Fig. 8).

The centrifugals consist of a series of baskets revolving at high speed, the periphery of which is perforated and lined with fine gauze. The massecuite, which is a mixture of sugar crystals and molasses, is discharged into the basket, and by centrifugal force the molasses is separated from the crystals, passing through the outer perforated drum. This molasses can be further treated in the vacuum pans, etc., and a further recovery of sugar of a lower grade made therefrom. The sugar is conveyed by means of an Archimedean screw to elevator, which raises the sugar into the upper floor of the sugar store. The sugar is then passed through the dryer (Fig. 9), where, by means of hot air, the last traces of moisture are driven off from the



Sections through Evaporator

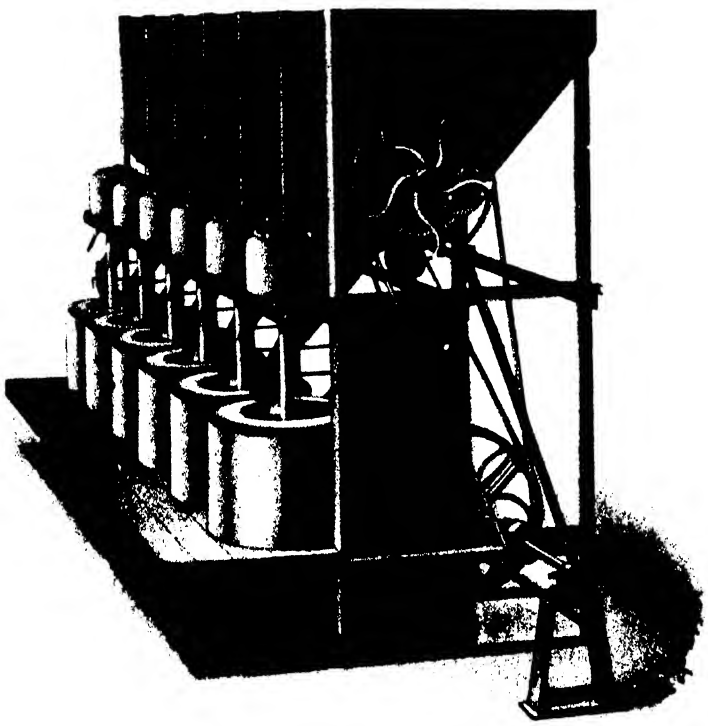


Fig. 8 Arrangement of Patent Belt-driven "Weston" Centrifugal Machines

sugar, so that it can be crushed and pulverised to suit the Indian market, or packed in crystal form and transported as may be required.

A further process of making white plantation sugar for the Indian market is by means of sulphurous acid gas, or sulphitation process as it is commonly called.

The juice from cane mill is limed and pumped into sulphitation tanks (Fig. 10). Sulphurous acid gas is generated in specially constructed furnaces (Fig. 11), where air is passed over burning sulphur. The juice in the sulphiting tanks is treated by means of this sulphurous gas, and is then passed through a series of juice heaters (Fig. 12), where the temperature is raised beyond boiling point at atmospheric pressure. The juice at almost boiling point is run into tanks, where it is allowed to subside, and the clear liquor decanted off at the top, and the dirty bottoms are taken away to be further subsided in the range of second subsiders. The clear juice from the first and second subsiders is taken to

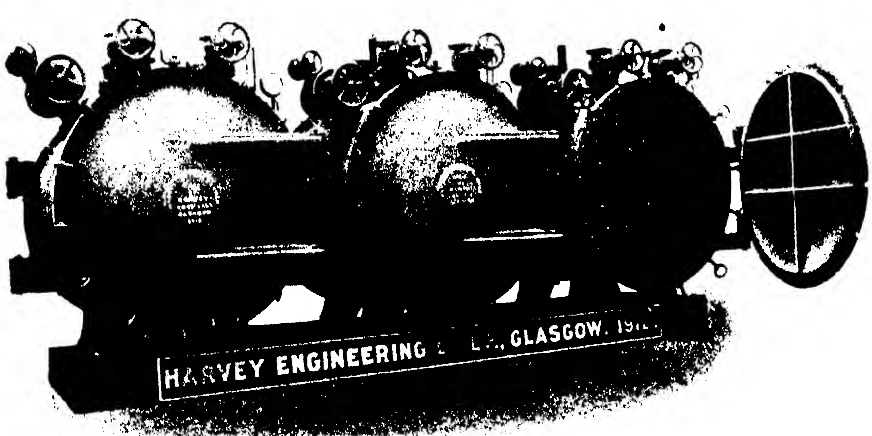


Fig. 12 Horizontal Juice Heaters

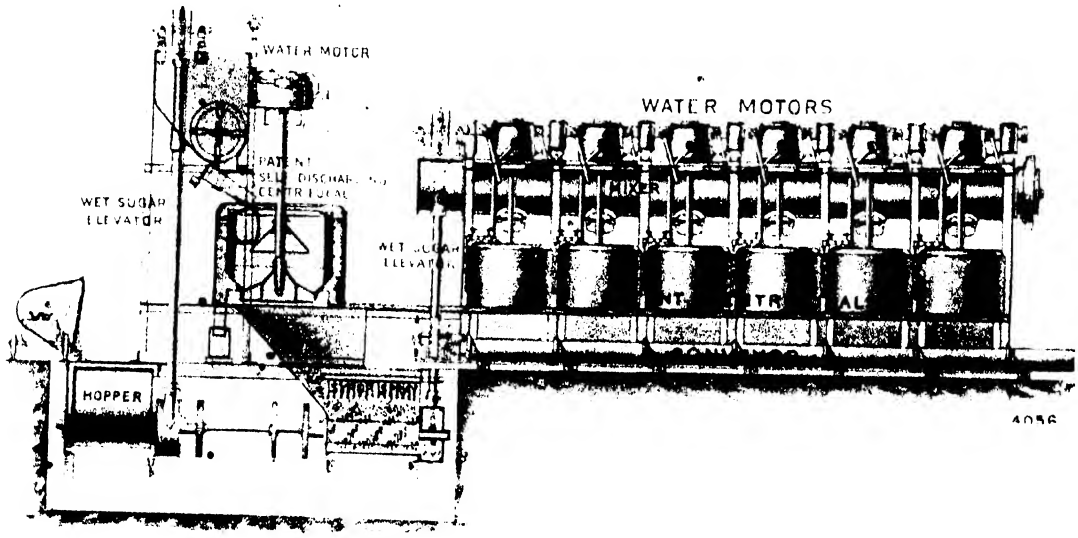


Fig. 14. Double Curing Plant

the triple or quadruple effet evaporator, and thereafter the process is similar to what is described above for making sugar on the carbonatation process, excepting that often double curing is used in combination with the sulphitation process. The double curing arrangement of centrifugals is shown in Fig. 14. The sugar crystals from the first machines are mixed with pure syrup and formed into a magma, elevated to the mixer of a second row of centrifugals, and the molasses or syrup separated from the crystals in the baskets. By this means a whiter grade of crystals is obtained, suitable for direct consumption.

(To be continued.)

Questions and Answers

(Continud from page 246)

Railway Works, Rochdale; Messrs. A. Ransome & Co. Ltd., 62 Queen Victoria Street, London, E.C.4.

QUESTION.

To the Editor, "Industrial India."

DEAR SIR,—We want to go in for "breaking down frame saw," an illustration of which is given at Fig. 3, page 466 of INDUSTRIAL INDIA, No. 9, Vol. I, April, 1922. We would therefore request you to give us the full address of the manufacturer of this machine.

ANSWER

DEAR SIRS,—Replying to your enquiry addressed to our Bombay office, in which you ask for the address of the manufacturers of the "breaking down frame saw" referred to in No. 9, Vol. I of INDUSTRIAL INDIA, we have pleasure in stating that the full title and address of the makers of this saw is as follows:—Messrs. Thomas Robinson & Son Ltd., Railway Works, Rochdale.

We have asked Messrs. Thomas Robinson & Son Ltd. to send you full particulars of this machine, in order to save time.

QUESTION.

To the Editor, "Industrial India."

Re "BRICK AND POTTERY MAKING."

DEAR SIR, As we are interested in the Marlow tunnel kiln, referred to in the above-mentioned article, we shall be obliged if you just let us have full address where we can make enquiries as regards the price, etc., for a complete Marlow oven.

ANSWER.

DEAR SIRS,—Replying to your enquiry addressed to our Bombay office, in which you ask for the address of the makers of the Marlow oven, we have pleasure in stating that the full title and address of this firm is as follows: The Hearthcote Pottery Co. Ltd., Swadlincote, Nr. Burton-on-Trent.

In order to save time, we have written Messrs. The Hearthcote Pottery Co. Ltd., asking them to send you full particulars.

In Great Britain there has been a marked improvement in the six-wheeled motor vehicle, which is designed to carry heavy loads with a moderate weight on each axle. Another type of vehicle which has been brought out in Great Britain for a somewhat similar purpose replaces the two steering wheels usually found on motor vehicles, with a set of four wheels. The extra pair of wheels is mounted on a second front axle, and so arranged that the steering action of all four wheels is the same as if only two wheels were installed.

QUESTIONS & ANSWERS

We shall be pleased to answer any question relating to industry, to advise in the starting of any particular branch of manufacture, to give expert advice on any power or power transmission problem, or to render any assistance possible in solving mechanical or technical problems. All questions should be addressed to the Editor, London

QUESTION.
To the Editor, "Industrial India."
Re MODERN WINDMILLS.

DEAR SIR,—Could you kindly let me know the address of any firm in Bombay or in America where I could get information about modern windmills?

ANSWER.

DEAR SIR—Replying to your enquiry addressed to our Bombay office, we have pleasure in sending you under separate cover to-day information which we have collected regarding "Modern Windmills."

This will enable you to get into direct touch with the makers for further information, but should you require any further assistance from ourselves, please let us know.

QUESTION.
To the Editor, "Industrial India."

DEAR SIR,—I shall feel obliged by you letting me have the following information:—

(1) I have a 50 H.P. Blackstone oil engine. It will be required to drive four stone flour mills, one rice huller, and one oil expeller. What will be the best belt to purchase, and where from?

(2) As you are no doubt aware this town is noted for its brassware; it is all beaten out by hand, which takes some considerable time. Would it be possible for me to purchase a kind of stamp that would stamp out such things as (*a*) brass tea trays measuring 10 or 12 in. by 1 ft. 6 in.; (*b*) brass plates out of which Mohammedans eat their meals; (*c*) brass cigarette trays (ash); (*d*) brass finger bowls? These articles are made by the hundreds here, but far more could be turned out if the workmen wished to work harder, and from conversations I have had with some of the leading merchants, I understand they are in the hands of the workmen. I am the station master of this place, but take a very keen interest in the advancement of India generally, and it hurts me to see the waste that is taking place daily, just for the sake of a good power plant.

(3) In April issue of INDUSTRIAL INDIA, page 457, you give an article on can making. Do you really think this would pay in this part of the country?

ANSWER.

DEAR SIR,—Replying to yours of the 25th June, in which you ask for certain information, we will deal with your questions in order.

(1) Regarding the best belt for driving your four stone flour mills, etc., from 50 H.P. Blackstone oil engine, there are a very large number of different makes of belting at present on the market, any one of which would be suitable for your purpose, and in such a case you will readily understand that we cannot set ourselves up as judges under the circumstances. To guide you in your decision, we would recommend you to our advertising pages, and we have, further, written to one of these firms, namely, Messrs. George Angus & Co. Ltd., 7 Bury Street, St. Mary Axe, London, E.C.3, whom, you will see, have their offices in different parts of India, asking this firm to write you direct on the subject. We have made an exception in this case because we happen to know that one of their principals has recently been making a personal study of the question of belt driving in India, and doubtless this firm will be able to give you some useful information on this point.

(2) Your question regarding the machinery for pressing brass tea trays, etc., is one which has been raised by a number of correspondents, and in each case we have passed the inquiry on to three of the principal makers of this class of machinery, asking them to forward direct to our correspondent full particulars of the plant necessary for the stamping of such articles as you mention. We have, therefore, passed your enquiries to the following firms:—Messrs. J. Rhodes & Sons Ltd., Grove Ironworks, Wakefield; Messrs. Taylor & Challen, Derwent Works, Birmingham, Messrs. E. W. Bliss & Co., Pocock Street, Blackfriars Road, London, S.E., asking them to be good enough to send you on this information. This will completely deal with your questions under this heading.

(3) Regarding your third question, as to whether can making would really pay in India, this is, of course, a matter which must be considered taking into account particular local conditions, and in writing our article we could, of course, only write taking a broad point of view, and there is no doubt whatever in our minds that there must be a very good opening for the manufacture of tin cans in India. We are, however, looking into this particular point more closely, and if we are able to obtain any specific information on this point which we think would be of interest to you, we will have pleasure in sending it on a little later.

QUESTION.
To the Editor, "Industrial India."

DEAR SIR,—We have read with interest the article in your February issue of INDUSTRIAL INDIA, on the subject of "Simplified Flour Milling" ("The Midget System"), and the other article in your April issue on the subject of "Cutting of Forests with Machinery," and shall thank you if you please give us the names and full addresses (or any literature on the subject) of its makers, or their Indian agents. We wonder what will be the cost of complete installations of these?

ANSWER.

DEAR SIRS,—Replying to your enquiry forwarded to us from our Bombay office, in which you ask for further particulars regarding the "Simplified Flour Milling" system and particulars of machinery for forest timber felling, referred to in the February issue of INDUSTRIAL INDIA, we have asked the firms concerned to send you full information direct as follows:—

Simplified Flour Milling: Messrs. A. R. Tattersal & Co., 75 Mark Lane, London, E.C.3.

Machinery for Forest Tree Felling: Messrs. T. Robinson & Son Ltd.,

(*Continued on page 245.*)

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

Low Temperature Carbonisation (vii)

(THE "MACLAURIN" PROCESS)

BY DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min E., Mem. Am. Soc. M.E., A.I.Mech.E, etc

THE "Maclaurin" process of low temperature carbonisation is the work of Mr. Robert Maclaurin, and is controlled by Messrs. Maclaurin Carbonisation Ltd., of Grangemouth, Scotland. It differs from all other processes, inasmuch as there is no external heating of the retort or producer. The coal is carbonised by the combustion of a small part of the coal charge in the retort itself, which may be stated, very roughly, to be on the principle of a very tall, narrow beehive coke oven, with the temperature under perfect control, and with the recovery of the whole of the valuable gaseous and volatile products, the choking of the draught caused by the installation of a recovery plant being compensated for by the addition of a mechanical forced draught air blast. This process was the outcome of Maclaurin's early work on oils, and his conviction—combined with Percy's statement that coals, when slowly heated, lose their power of cohering—that coal should be carbonised gradually, in such a manner that the oils formed should be separated at once, and not allowed to trickle back into the hot zone and be decomposed.

Maclaurin laid his scheme before the Smokeless Fuel Committee of the Glasgow Corporation and the City Electrical Engineer, and eventually work was undertaken in 1915 at Port Dundas Power Station, jointly by the Gas and Electricity Committees of the Glasgow Corporation, a plant being put down under Maclaurin's direction. This plant was erected with two retorts, side by side, one more particularly for the production of smokeless fuel and illuminating gas, and the other for power gas, both with oil and ammonia recovery. A large amount of valuable experimental work was carried out on this plant, but the war repeatedly hampered the operations, which were finally stopped on this account.

It was definitely established, however, that by the "Maclaurin" process coal could be carbonised and converted into a smokeless fuel by the passage through it of 13,000—20,000 cubic feet of hot power gas per ton much less than was generally believed. The residual smokeless fuel contained 4 per cent. volatile matter, and was easily kindled and absolutely smokeless. The oils produced were very complicated in composition, the thermal value of the gas was lower than was expected, and the yield of ammonia was fairly good, with an absence of ferrocyanides and sulphocyanides, but containing complex trihydric phenols, and, finally, that the plant would work quite well even with coking coals without being jambed up. Two of the troubles experienced, however, were that there was no market for the oil, because of its unusual and unknown composition, and the fact that the smokeless fuel "crackled" very badly when burning. It was subsequently discovered, however, that this latter objectionable property was due to the use of a water seal at the bottom of the retort, and when this was altered the trouble ceased.

When the plant at Port Dundas was finally shut down, a small plant capable of carbonising 1 cwt. of coal per hour, was erected at Stirling, and much experimental work was carried on with regard to the composition of the oils, whilst also a method was evolved of discharging the hot residual fuel from the retorts without the use of a water seal. Subsequently a site at Grangemouth was secured, adjoining Scottish Dyes Ltd., one of the directors of the latter company being also a director of Messrs. Maclaurin Carbonisation Ltd., and a full-size plant erected, as illustrated in Figs. 1 and 2, capable of carbonising 20 tons of coal a day.

As seen in the illustrations, the firebrick retort resembles an elongated producer or small blast furnace, the overall height being 40 feet—much higher than in any other process,—and the width at the zone of maximum combustion, the widest portion, being about 8 feet. The coal is fed in at the top, and the retort has all the advantages of the intermittent vertical gas retort of the use of gravity in causing the coal to travel downwards through the retort, and the consequent reduced amount of labour necessary. The residual fuel is extracted as required from the bottom by a special extractor without the use of water, and an air blast, supplied by a small blower, is admitted at the zone of maximum combustion. Part of the fuel is burnt in this portion of the retort, the maximum temperature with usual working being about 1,290 deg. F. (700 deg. C.). The hot gases and volatile products pass upwards through the descending fuel, so that there is a slow and gradual carbonisation, increasing as the charge descends to the hottest zone. The total time of travel through the retort is 20 hours, the output being at the rate of nearly 1 ton per hour. The consequence is that the oils and volatile products driven off at each succeeding stage of the carbonisation pass upwards into a cooler zone, and are condensed in the top layers of practically cold fuel, and the oils are trapped so that they cannot trickle back and pass off along with the gases through a horizontal outlet pipe near the top of the retort, as seen in Fig. 2. It is found in practice that this slow and gradual carbonisation avoids practically all trouble of sticking and jambing, except with very strongly coking coals.

The Retort

The "Maclaurin" retort is claimed to be particularly adaptable both in

the method of working, and in the variety of coals that can be carbonised. The air blast can be regulated according to the results required. Thus with a moderate blast, a dark-coloured, smokeless, easily-ignited, household fuel is produced with 20,000 cubic feet of gas per ton, but with an increased blast and 30,000-40,000 cubic feet of gas per ton, the residual fuel is a hard, silvery coke, suitable for metallurgical purposes. The process can also be changed easily to complete gasification. A great variety of fuels can be carbonised, non-coking as well as coking, and low grade and refuse fuels of the right size are stated to present little difficulty, even with 50 per cent. ash. The size of the coal carbonised can vary from small nuts to lumps 8 in. to 9 in. cube, but it is not so satisfactory with dross and fine slack.

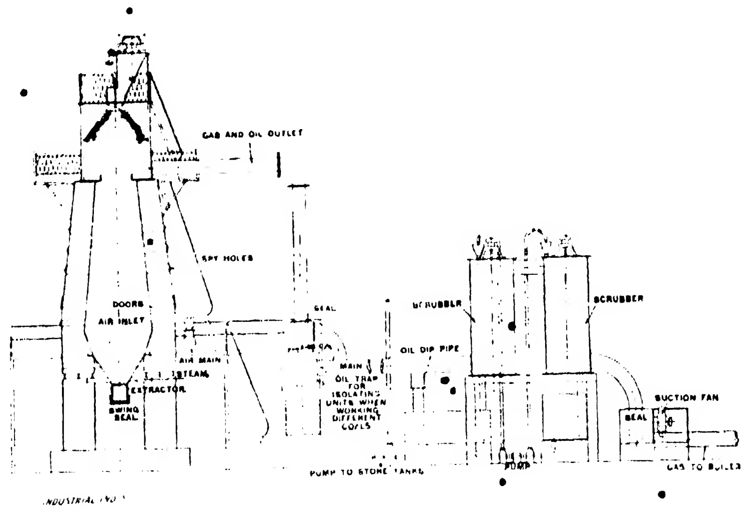
Since all the heating is internal, the total heat losses in the "Maclaurin" process are very small, consisting only of the radiation losses of the retort, the heat in the gases leaving the producer, and the hot residual fuel. The walls of the producer are, however, very thick, and the radiation losses are very small, whilst the gases do not leave the top of the retort at much more than 140 to 175 deg. F. (60 to 80 deg. C.), which reduces the total heat losses to a minimum, whilst also minimising the subsequent work required by the coolers and scrubbers.

As typical of the yield obtained by the "Maclaurin" process, we can take the case of a coal containing 35 per cent. volatile matter and 7¾ per cent. water, with a heating value of 12,300 B.Th.U.'s., the figures being as follows for a given method of working. It is particularly difficult, however, to give what may be termed true average figures, since not only is there great variation in the yields from coals of slightly different elementary composition, but the air blast is very sensitive, and can be varied within fine limits so as to alter the gas yield and consequently also the other products.

YIELD FROM 1 TON OF AVERAGE COAL.

(12,300 B.Th.U. 35% Volatile.)

(1) 27,731 cubic feet of gas at 247 B.Th.U. per cubic foot.
(2) 15.6 gallons oil (dry) of 16,600 B.Th.U.
(3) 15 lb. sulphate of ammonia, and
(4) 10.96 cwt. of smokeless fuel, as follows:—
   (a) 8.05 cwt. large coke (smokeless fuel), 12,600 B.Th.U.
   (b) 1.16 cwt. smithy char., 12,196 B.Th.U.
   (c) 0.76 cwt. peas, 11,283 B.Th.U.
   (d) 0.99 cwt. breeze or dust, 9,203 B.Th.U.



Arrangement of Plant

Taking now the various products in order:

(1) *Gas.* The amount and composition of the gas obviously depends upon the method of working the blast. For the production of smokeless household fuel the yield is usually 20,000 to 25,000 cubic feet per ton of low grade power quality, say 200 to 250 B.Th.U's. per cubic foot. The following is what may be termed a fair average composition of this quality of gas, taken over a 24-hour run:—

CO_2 (carbon dioxide)	6.2%
C_nH_{2n} (illuminants)	nil
CO (carbon monoxide) ...	16.0%
CH_4 (methane)	13.0%
O_2 (oxygen)	0.6%
H_2 (hydrogen)	16.1%
N_2 (nitrogen)	48.1%
Heating value	247 B.Th.U. (gross)

The entire absence of hydrocarbons other than methane is very curious, and is due to the almost complete absence of cracking of the oils during the process of carbonisation. The gas is easily scrubbed and cleaned, as it is almost entirely free from tarry material, and is very suitable for power or heating purposes. If a low grade power gas only is required, with complete gasification and the separation only of the oils and ammonia, steam can be blown into the retort along with the air blast. The average composition of the gas of this nature is 12.9% CO_2, 0.9% O_2, 0.2% C_nH_{2n}, 5.6% CO, 10.0% CH_4, 8.9% H_2, and 61.5% N_2, with a heating value of 135 B.Th.U's. per cubic foot.

(2) *Oil.*—The oil produced can be taken as 15-20 gallons to the ton, and remains the same with a given coal, irrespective of the method of working the air blast. The composition of the oil is most peculiar. In the first place it is quite different from ordinary low temperature carbonisation oils, since it contains practically no light oils, due to the entire absence of cracking during carbonisation, which is characteristic of externally fired retorts. The oil is, however, a true low temperature product in the sense that it has no naphthalene or anthracene. It is characteristic as containing a large percentage of phenols, the lighter distillates containing 50% of cresols and xylenols. There is also a large proportion of high-boiling point 445 deg. to 570 deg. F. (230 deg. to 300 deg. C.) phenols, whilst the distillate over 515 deg. F. (270 deg. C.) contains a considerable percentage of solid paraffins. The crude oil has a heating value of about 16,000 to 17,000 B.Th.U's. per lb., and is very satisfactory as a fuel oil, whilst portions can be used as "Diesel" oil, and also as lubricating oils.

(3) *Ammonia.*—The yield of ammonia is difficult to state in terms of average figures, as apart from the constitution of the coal, the figure increases in proportion to the amount of the air blast. Thus when working the plant for hard coke, 24 lb. per ton can be obtained, but for ordinary low temperature working the figure is, say, 10 to 20 lb. It is characteristic also of this process that the ammoniacal liquors are free from ferrocyanides and sulphocyanides, but contain di- and tri-hydroxy phenols dissolved out from the large amounts of phenols in the tar.

(4) *Smokeless Fuel.* With a moderate blast for what may be termed normal low temperature working, the residual smokeless fuel contains about 4% of volatile matter. It is as hard

as gasworks coke, but is black in colour and not grey like coke, whilst it is much more easily ignited than gasworks coke, forming, therefore, an ideal household fuel. As with other low temperature fuels, the small percentage of volatile matter does not prevent the easy ignition. Mr. Peter Fyfe, secretary of the Coal Smoke Abatement Society, found that the fuel kindled and came to full redness more quickly than coal, and it burns in ordinary household grates with a high emission of radiant heat. Also it has been found to be particularly suitable for steam generation, as extended trials in Glasgow have proved. As already stated, if the blast is worked at the top limit, the residual fuel is different in properties, and practically equal to metallurgical coke, being very hard, and, like coke, not suited for domestic use, if only because of its difficult ignition. A curious fact is that during carbonisation any shale or stony material in the coal tends to separate from the bulk, and on this account a smokeless fuel is often obtained with no more ash than the original coal, a large portion of the mineral matter having been bodily separated or passed into the breeze.

The "Maclaurin" process seems to be particularly interesting in connection with the utilisation of low grade fuels, especially of an anthracitic character, a very difficult proposition. Some typical results are given below with such varied material as canneloid low-grade fuel, refuse bituminous coal, and anthracite refuse :

Analysis of Fuel.	Canneloid No. 1 %	Bituminous No. 2 %	Anthracite No. 3 %
Moisture ...	0.70	2.22	1.22
Volatile Matter ...	26.04	19.02	6.72
Fixed Carbon ...	23.52	26.48	36.48
Ash ...	49.74	52.28	55.58
	100.00	100.00	100.00
Yields obtained per ton.			
(1) Gas in cubic feet of 150 B.Th.U. ...	46,767	69,240	60,800
(2) Oil (gallons) ...	25.8	6.7	2.0
(3) Sulphate of ammonia (lb.) ...	8.5	17.0	10.3
Calorific Efficiency of test run ...	80.7%	88%	72%

As regards the balance sheets of the process, Table I is a typical example with 1 ton of coal at 12,000 B.Th.U's. (26,880,000 B.Th.U's. per ton).

As regards the heat balance sheet, this is naturally very satisfactory, because of the internal heating, and it will be noticed that the efficiency of the process from the original coal is

Yield	Corresponding B.Th.U.	Value of Products.
(1) 20,000 cubic feet of gas at 200 B.Th.U. ...	4,000,000	6 8
(2) 20 gallons oil (170,000 B.Th.U. per gallon) ...	3,400,000	12 9
(3) 12 cwt. residual smokeless fuel ...	17,600,000	22 0
(4) Ammonia, 24 lb. 0 1 ...		2 0
(5) Less in process ...	1,800,000	
	26,880,000	43-5

Table I

$$\frac{25,080,000}{26,880,000} \quad 93\tfrac{1}{3}\%$$

In the typical example given at the commencement of the article, 1 ton of the coal at 12,300 B.Th.U's. contains 27,552,000 B.Th.U's. The 10.96 cwt. smokeless fuel contains, with the various qualities together, 24,447,657 B.Th.U's., whilst the oil contains 2,672,600 B.Th.U's., and the gas 6,849,537, making a total of 24,447,657 corresponding to an efficiency of 89.7%, or a loss of only 11.3% of the original heat of the coal.

The value of the coal taken in the above balance sheet is 33/6 per ton, and the values taken throughout are based on the residual smokeless fuel being equal in therm value to coal, the gas being equal to 0/2 per therm, and each therm in the oil as worth three times a therm in the coal, which, on present market prices of coal and oil, is a fair assumption.

The capital cost required for a plant of 100 tons a day is approximately £20,000, and allowing 10% for depreciation, 10% for repairs, stores, and running charges, 5/- per ton for labour, together with the 33/6 per ton for coal, the cost per ton would be as follows :

Coal ...	33/6
Labour ...	5/-
Depreciation on plant ...	1/4
Maintenance and repairs ...	1/4
	41/2

being a total cost of 41/2, leaving a profit, therefore, of 2/3 per ton, since the revenue as already stated was 43/5, corresponding to 16½% on the capital.

The capital cost of the "Maclaurin" plant is low because of its extreme simplicity, whilst the depreciation is also low because of the small area of highly heated brickwork. As already stated, the labour charges are at a minimum because the retort is practically continuous. Looking at it in another way, Mr. Maclaurin states that with coal at 20/-, if the crude oil is taken as only worth 0/4 per gallon, and the ammonia ½d. per lb., the gas and the coke, without allowing for the breeze, would only have to fetch 20/- per ton to make the process pay. If the gas was sold in competition with producer gas at 2-3 pence per therm, the smokeless fuel could then be sold at 15/-. Or, if the large clean coke only was sold at 28/- for furnace work, a fair value with coal at 20/-, then the gas could be sold at 1.24 pence per therm. It is obvious, therefore, that the whole process presents most valuable possibilities.

Nature of Coal.	Percentage volatile matter	Probable yield of oil in gallons per ton of coal.
Steam ...	20-25%	6-12
Coking ...	30-40%	12-16
Non-coking ...	30-40%	16-24
Cannel ...	30-40%	24-60

Table II

(*Continued on page 272.*)

The Manufacture of Shuttles

A short article of much interest to the Textile Industry

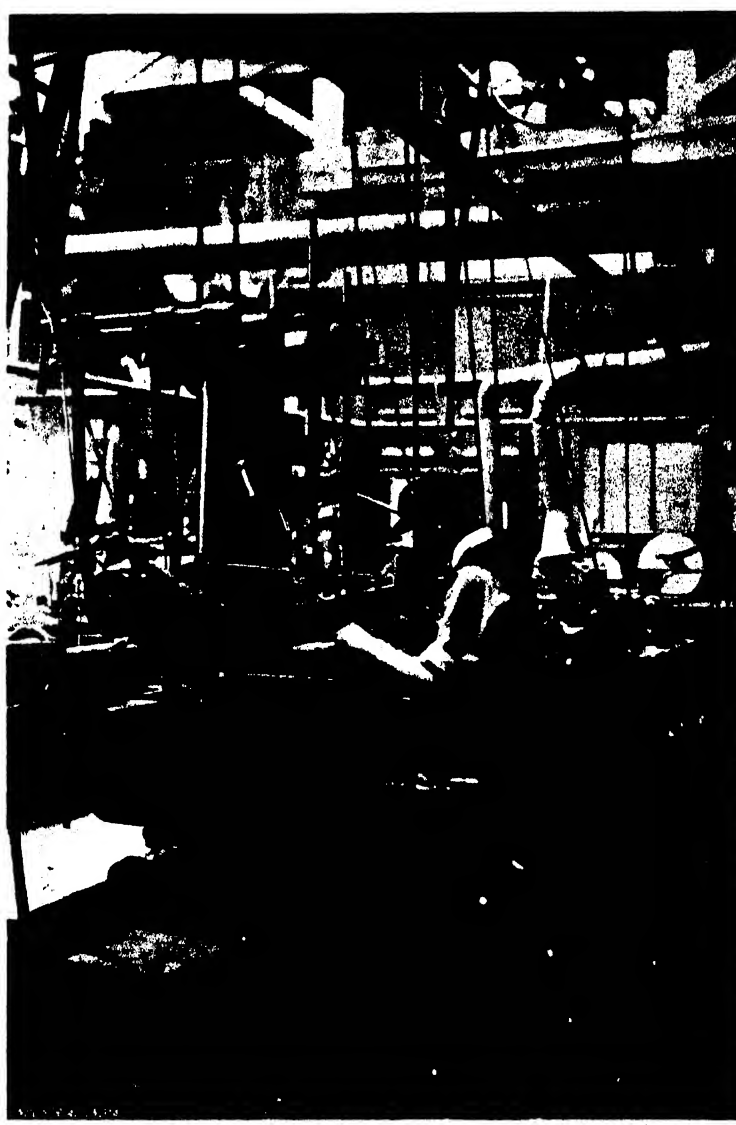
THE unlimited area of scope of production which the textile industry covers is indeed remarkable, and it would indeed be a very difficult problem to define its limitations. The accessories necessary for the process of manufacture are innumerable, and many industries rely on the textile industry, for without the latter their productions would not be necessary. From the engineering parts of power requisite to run a factory down to the simplest production in the shape of picking sticks, reeds and healds, bobbins, shuttles, etc., there are a vast number of people employed to keep the factory in a state of efficiency.

Shuttle-making is not by any means one of the least important, for the steel-tipped cigar-cradle-like shuttle is the vital factor of the loom, the reciprocating medium for linking together by traverse the warp and the weft.

Going back to the earliest days, when the garret eight houses in Lancashire and Yorkshire used to be lit up for weaving purposes, the village joiner used to make the wooden looms, with their big, heavy gallow baulks, whilst at the present day shuttle production is one of the loom accessories. Wood as yet appears to be the base, or rather the portion, which forms the body of the shuttle, and it still remains in its cigar-like shape with the steel-tipped ends.

Now the wood from which shuttles are made must be of a hard, tenacious kind, one that will assume a polished, firm surface, and a good resistance to collapsing, hence trees of the hardwood kind meet the purpose exceedingly well, also of not too large a girth, the smaller the girth and greater the tenacity. Not only that, but the wood must be in a proper seasoned state; quick stove seasoning does not add to the life of shuttles, the tendency is to make the wood too brittle, the naturalness of the wood is destroyed. This method of seasoning wood cannot be too strongly condemned in other industries where wood occupies a prominent feature.

The making of the shuttle from the log, as it were, to the loom is very interesting. Like the bobbin industry, the shuttle maker, as a general rule, buys the wood in its log state, *i.e.*, not sawn up, from the timber merchant, as is often done in other industries. There is an advantage in this, for, as a rule, the hard woods used are of a costly kind, and it requires economic conversion to get the best out of a log, and who should know better the best way of conversion than the actual producers themselves. Incidentally, it may be noted conversion of a log means something more than the cutting up into suitable pieces for making the shuttles, the twist and the curl of the grain must be watched, for on this depends, to a large extent, the life of the shuttle.



Placing tips on the ends of the wooden shuttles

The first operation in the making of a shuttle is to cut the pieces of wood into rectangular slabs, to give it the shuttle-maker's trade term. These are pieces of wood of the shape named, and longer than the length of the shuttle roughly sawn square. The next is planing by machinery the slabs, getting the sides square to each other. This is very important, because, in production, truth is everything, especially where mechanical principles are involved.

The next process is bodying, where the inside is rotated out by a series of circular cutters for the bobbin itself to fit in, and in this process the portion taken out leaves a surface almost as good as the outside.

The next process is tipping, and the tips themselves must be tempered to a certain degree of hardness not too dead hard and brittle, but such as to be in a state to give resistance to injury by the ever almost constant reciprocating action of the shuttle when in the loom. These tips should be in the centre of the shuttle when finished, and it will be noticed that there are many details and specialised processes for the cigar-shaped shuttle to pass through before it is ready for finishing. Of course, in woods like the box and cornel, there is admittedly little chance of the grain splintering in good material, so dead hard are the woods mentioned. A high finish is desirable, for anything which impedes the travel of the shuttle does not add to its efficiency.

The loom itself has changed tremendously in many of the textile industries almost past recognition. The same applies, in a much lesser degree, to the shuttle, but the first principles still form the base of production.

Cutting out the slabs

Many shuttle firms also make the necessary picking-stick, the handmaid of the shuttle. To the manufacturer these small detailed parts of the machinery are vital factors to be watched. They are consumable during the process of production. The long living, as it were, of the shuttle, picking-sticks, bobbins, etc., lessen the ultimate cost of production, hence it follows that the best finish, the best produced, are the most reliable, and gives the best results, for, when all is said and done, shuttles probably cause the most wear and tear on the loom.

As in all these so-called minor, but important, industries, the producers, as it were, improve their own machines, which are known to each individual producer, and many interesting and often ingenious contrivance helps to either get a better finish or lessen the time of production.

In conclusion, it may be added British made shuttles have a high reputation. They stand for quality, and the shuttle maker well maintains the tradition.

Modern Grinding Wheels

The following article describes the complete process of making modern abrasive wheels. We are indebted to The Universal Grinding Wheel Co. Ltd., Stafford, for the data supplied, and also for the loan of all photographs.

ONE of the most important developments in Engineering practice to-day is the ever increasing use of Abrasive Wheels.

In reading about Grinding Wheels, the mind at once flies to the old Grind Stone, with an iron crank handle on which domestic knives, etc., are sharpened. This must be entirely put away if a proper conception is to be arrived at of what a modern grinding wheel really is. In its modern application a grinding wheel is essentially a metal removing tool, that is to say that its invention has very largely displaced a lathe, milling machine, planing machine, a file or even a saw. True, it is still used as a sharpening medium, and in this line numerous quantities are used, especially for saws. Without the valuable aid of this tool many engineering operations in connection with the war would have been impossible. All parts of guns, moving parts of motor cars, armour plate, etc.,

Mixing Room

require the hardest steel that can be produced, so hard are these parts that the only method of machining them is by means of hard abrasives bonded into a cutting wheel. These parts in many cases required to be finished to the ten thousandth part of an inch, and by the co-operation of the machine tool maker with the wheel maker in producing the grinding machine on which the wheel has to be operated this has become comparatively simple.

To economically produce these specialised articles in large quantities it was found that every kind of material and almost every different shape and size of a given material required a specialised grinding wheel. Grinding and the manufacture of grinding wheels therefore, has become one of the most intricate of industrial sciences. It has been developed for the last 40 years in the U.S.A., to a very high degree of perfection. Some of the largest works have on their staffs Chemists, Physicists, Ceramicists and well equipped Research Laboratories.

The making of a grinding wheel depends largely on ceramics and engineering, and it is England that is preminent in pottery knowledge, and it certainly lags behind no other in engineering. It was, therefore, somewhat discreditable that England should have left this large and essential industry to America. This, however, is no longer true, and important works have recently been developed where research is conducted and results obtained that give the lead to anything hitherto done in the United States. This is notably so at Stafford, where the Universal Grinding Wheel Co. Ltd., have a works equipped with 19 ovens and providing work for about 700 people when fully employed.

The British Fight

A fight for the world's trade in grinding wheels, is, however, a somewhat uphill one for the British manufacturer, in that American representatives and publicity methods have had undisputed sway with engineers for the last 40 years. It is hoped, however, to combat this by maintaining the excellence of the British article, and by taking full advantage of the fact that engineers everywhere know that Britishers do not export their goods until they are the best possible.

Not only have British manufacturers succeeded in emulating American abrasive wheels, but they have recently perfected a range of sharpening stones such as are used in all sorts of hand operations, more particularly in agriculture. These stones are great labour savers, they are especially applicable to scythes and reaper knives. They owe their excellence largely to a deposit of very pure corundum, which is also found in the Empire, viz., in South Africa.

The Manufacture of Vitrified Grinding Wheels

Grinding Wheels according to their method of manufacture may be divided into two classes.

(1) Those made by the Vitrified Processes.

(2) Those made by one or other of the four or five processes known as the cold bonded processes.

For the purpose of this article, we propose to deal with the first of these classes.

Vitrified grinding wheels comprise at least 75 per cent. of the grinding wheels in use, and are continually replacing those made by the older methods. It is still the case, however, that for certain purposes, wheels made by one or other of the cold bonded methods are necessary.

For example — Grinding on Aluminium, Bevelling of Glass, and therefore very thin wheels have to be used.

Grinding wheels may again be divided into three main classes, according to the purpose for which they are to be used.

(1) Rough grinding wheels for uses such as fettling castings, and rough grinding manganese steel.

(2) Wheels for grinding tools by hand.

(3) Precision wheels.

It is this latter class (3) that calls for the greatest care and skill in manufacture.

They have to be so produced that they can be relied on in the hands of semi-skilled or totally unskilled operators of the finest engineering parts, accurately to the 1/10,000 part of an inch. They have to be made in an ever occurring number of grits and hardness to suit the ever growing complexities and varieties of the materials they have to grind, and each must be accurately made for the purpose for which it is designed.

For Class (1) Rough grinding wheels and Class (2) Tool grinding wheels, the accuracy demanded is not quite as great, but the processes of vitrification are essentially the same.

Abrasive wheels consists of two parts, namely :—

(*a*) The abrasive which does the cutting or grinding.

(*b*) The bond or matrix in which the abrasive is embedded, and by which it is held together.

The abrasives used are various and are selected according to the ultimate purposes for which the wheel has to be

used. This again may be divided into two main classes.

(1) Naturally occuring abrasives.
(2) Artificial abrasives.

Of the naturally occuring abrasives "Emery" is the oldest and the best known. It is a rock composed of an impure form of micro-crystalline alumina, the impurities in which are mainly oxide of iron, amounting to as high a figure as 40 per cent. Its classic locality is the island of Naxos in the Ægean Sea. There are also Emery mines or quarries in or near Smyrna, and some inferior varieties are found in parts of the United States of America. Emery is not often used alone in grinding, but is useful when mixed with other abrasives to give a wheel durability, and this quality is especially useful in the grinding of manganese steel.

"Corundum" is the most important naturally occuring abrasive. It occurs in two forms—the boulder micro-crystalline form and the crystalline form. It is found often in quite large crystals, the mineral crystalising in the hexagonal system. Chemically it is oxide of alumina in a high degree of purity, the impurities being mica and oxide of iron. The classic locality for corundum is the Craig Mine, Canada. This mine is now nearly worked out, and during the war the search for supplies of this material was vigorously taken up by the Ministry of Munitions, and beds of it were discovered in various parts of the world. Notably in the Transvaal in South Africa where it lies in large quantities, in both the boulder and crystalline form. Some excellent corundum is also found in Madagascar. India also has several beds, but the Indian corundum has not been found suitable for the making of vitrified wheels. Corundum as an abrasive is used largely alone, and frequently in conjunction with other abrasives. It is especially useful in the grinding of steel tools, cutting fast and keeping comparatively cool. It is also the most satisfactory abrasive hitherto tried for grinding glass. Other naturally occuring abrasives such as garnet and quartz are not used in the manufacture of vitrified grinding wheels.

Artificial Abrasives

These again may be divided into two classes.

(*a*) Those produced by fusing aluminous material.
(*b*) Those produced by the intrication of carbon and silicon at a high temperature.

To take the aluminous abrasives first. The Norton Company of Worcester, Mass., are the pioneers of the artificial aluminous abrasive. Being dissatisfied with the results obtained from corundum and doubtful about the continuance of the supply they sought another source. Americans seem to have started from a notion that the higher the alumina content of the corundum, the better its abrasive qualities. They therefore sought for a deposit of alumina as fine as possible, thinking that by purifying this and then fusing it, they would get the abrasive they wanted. The result has nearly justified this belief.

Bauxite, the raw material for alumina, is what they worked on, and the resultant material which they call alundum is a very fine product. The Bauxite is mined at Beau in France, is imported to America as calcined and then passed through large electric furnaces at Niagara, and then cheeked. Each cheek in large electric fans, weighing about 2½ tons.

Several other firms besides the Norton Company produce artificial aluminous abrasives, calling the resultant abrasives by various names, such as aloxite, lionite, electrite corundum, etc. This product of artificial aluminous abrasive has become quite a big industry, and is mainly centred about the Canadian side of the Niagara Falls, but Bauxite is also fused in France in the Pyrences, in Norway, in Sweden, and even in Newcastle-on-Tyne, and Airdrie, near Glasgow. There are also several other sources of supply for Bauxite besides Beau, large deposits occuring in Ireland, but although attempts have been made to produce abrasives from them (notably in Wolverhampton), owing to their silica and iron content there has not been much success. Recently large deposits of Bauxite have been found in British Guiana, and this is the purest bauxite hitherto found. The Americans have already secured large concessions to work them, but during the war at the instigation of the Ministry of Munitions the British Government refused to sanction any more concessions to foreigners, and are trying to get the matter taken up in this country. They believe that there is a great future in British Guiana for the abrasive and the alumina industry, British Guiana it is reported having better facilities for the development of water power than any other country in the world.

Fused aluminous abrasives are specially useful for grinding all kinds of steel. In the United States of America corundum and other artificial abrasives have been almost entirely superceded by these abrasives. This however may not be entirely due to their superiority, but to the fact that the corundum in the Craig Mine is worked out.

Trueing Shop

The second class of artificial abrasives are those formed by the natural action of carbon and silicon at a high temperature. This material is chemical silicon, carbide (SiC.) is known by many trade names, but is familiarly known by the name of carborundum, and the materials necessary for its manufacture are coke of a very high carbon content and silica sand. These are put together and mixed with a little salt and sawdust. The furnaces consist of a long heap of the raw material about 20 ft. by 4 ft. by 5 ft., supported at each end by permanent walls, at the sides by loose firebricks. Through the permanent walls are heavy carbon electrolls, and a cord of carbon is placed through the raw material from one side of the furnace to the other, thus connecting the electrolls.

A current of about 2,000 H.P. is used and the length of round is about 36 hours. The temperature obtained is something of the intensity of 2,000 degrees.

After the furnace has cooled down, the outer crust is removed and the crystaline carborundum, which forms in zones round the cord is removed and is then washed in an acid bath and an alkali bath, and then grated into sieves for the use of the wheel maker.

During the war, owing to the difficulty in shipping, it became necessary to consider the possibility of manufacture of silicon carbide in England. As carborundum is also required as a refractory for furnace running, this work was taken up by the Leeds Fireclay Co. After considerable experiments they were successful. The manufacture by them however has not been proceeded with, as with the power changes obtaining it is not possible to compete with Niagara product. The Carborundum Co. at Niagara have a contract with the Niagara Falls Power Co., which gives them power at approximately 1/10 of a penny per unit, it taking five units of electricity to produce 1 lb. of carbo.

Silicon Carbide, known by one or other of its trade names, is also produced in the Pyrenees, in Sweden, and Canada. The Norton Co. also have their own product, which they call Crystolon.

Carborundun is the next hardest material known to Diamond. It is unquestionably the best substance available to-day for grinding cast iron, and it is also used for grinding brass, and other metals of low tensile strength.

The method of preparing the raw abrasive for the use of the wheel maker is as follows :—The boulder or ingot, as the case may be, which weight two or three cwts. at least, is placed on a steel plate on a thick concrete foundation, and a steel ball is hoisted to a height of 40 ft., by a crane, and from this height is let fall on to the ingot. The ingot does not always break the first time, but the crane is wound up again and again, until the ingot is broken into pieces small enough to be dealt with by an ordinary steel jaw crusher. From the jaw crusher the material passes to heavy steel rolls, which rolls are adjustable to crush fine or coarse as the case may be. The material is then graded by passing over a series of sieves, which separates it into various sized particles, numbered according to the number of holes to the lineal 1 in. of the sieve through which each fraction will just not pass. Thus a powder which will pass through a sieve having 40 meshes to the lineal inch, and will not pass through one having 46, is graded 46. It is this size 46 that is perhaps the most useful size in precision grinding. The finest fractions, finer than 250 are graded by an elutriation process, and are called 10 minute—20 minute —or 30 minute powder, according to the time they take to settle in water. The highest class abrasives before being used are passed first over an electric magnet of low potential to remove all particles of iron that may have been introduced during the crushing process, and the very best undergo a further magnetic process in a special machine made by the Rapid Magnetting Co., Birmingham, and they are passed through the fie'd of an electric magnet with a very high potential, this removes any iron impurities and it is possible with this machine to remove Mica, if it contains enough iron to stain brown. To turn next to the second process of the wheel, that is the bond. This consists of Felspar and special highly plastic clays. This process requires the clay to be dry, and in a very fine state of semi-division. To obtain this state of sub-division is not as easy as it sounds. Clay of high plasticity being not only very difficult to dry, but being very hygroscopic is very difficult to keep dry when it is dry.

Great Britain is one of the most wonderful countries, geologically speaking, in the world, and is lucky from a grinding wheel point of view to have clays of such multitudinous varieties available in the West of England, and it is all the more shame to have left the initiation development of this big industry to the United States of America.

Testing Room

Before starting the actual description of the wheel making proper, it is important to keep in mind what qualities we are to get in our ultimate product. First of all it is necessary that all precision grinding wheels must be in perfect, that is to say, it must be absolutely homogeneous, no one part must be denser than another. This is necessary for two reasons (1) If one part is denser than another the denser part will be harder, and therefore the wheel in use will not wear round, but will readily become out of truth. (2) If the wheel is out of balance no matter how rigid the grinding machine on which it is used may be, owing to the high speed of operation up to 6,500 peripheral feet per minute, chatter will be set up, which chatter will render accurate precision work very difficult.

A Corner of the Drying Room

Regulating Hardness

The next quality required is absolute hardness, that is to say that each wheel in a batch, and each successive batch of wheels that are designed to be the same hardness must actually be so. When once the correct hardness of wheel has been obtained for a particular job, it is very necessary that that exact hardness should be maintained. It is a common taunt of American Wheel Makers that British Wheel Makers sometimes make a good wheel, but that they cannot repeat the hardness. Whatever may have been the case in the past this is not true to-day.

Bearing in mind these two qualities of hardness and balance, we come to the actual processes (1) First, the abrasive, previously graded for size, is weighed out, and also the various clays, etc., forming the bond. It is by varying the proportion of the ingredients of the bond that it is possible to vary the hardness of the final product, and it will be understood how important it is that this weighing should be done accurately, especially as the process is a long one, and a mistake made here cannot be discovered until the wheel reaches its last stage. To the various ingredients thus weighed out is added water, and the whole is mixed in what is known as a blunger to a mass resembling in its outward appearance and consistency thick porridge. After about one hour in this machine the porridge is ready. It is then run into rough moulds, standing on paper on a plaster slab. The moulds are simply rings of tinned iron, very similar to ordinary domestic cake tins. The size of these rings should be 2 in. larger in diameter than the wheel will ultimately be, and the porridge should be poured to a depth of about 1 in. deeper than the thickness of the wheel. Thus a wheel that is to be 12 in. diameter by 1 in. thick will be poured into a rim 14 in. diameter to a depth of 2 in. The plaster slabs carrying the rims containing the porridge are then rocked or shaken to remove air bubbles. Then these are taken to the drying room. The drying is a difficult process, great care having to be taken that the temperature of the room remains constant, and that one part does not become hotter than another, if this occurs, cracks appear in the wheels and they have to be scrapped. The temperature of the drying room is controlled by recording thermometers. The method of heating found most satisfactory is by high pressure hot water, the temperature required being about 100 degrees F. The embryo wheel or blank as it is called remains in this drying room for a period varying from three days to three weeks, according to the size of the wheels. Before this period elapses, however, it becomes hard enough for the rim of the slab to be removed

The blank is now turned on a horizontal table revolving on a vertical axis. In this stage the blank 14 in. by 2 in. referred to above is turned to 12 in by 1 in., leaving, however, about 1/32 part of an inch for the final stage after baking. The cutting tools used in this state are made from old files, and their engineering angle is so arranged that they keep themselves sharp. In this stage also are shaped the various cup wheels, saucer wheels, that the different grinding jobs demand. All the various intricate shapes are cut from a solid blank. The blanks in this stage though brittle can be handled with comparative ease. After they are shaped the wheels are now more or less in their final dimensions, and they pass to the drying room once more to ensure that all trace of moisture is removed before they are placed in the ovens or kilns. These kilns are of special construction, and have been developed as the Universal Co's. experience dictated, each new one having had embodied in it our experience of its predecessor. It is very essential that the temperature should be the same all over, and that it should be possible to cool very slowly.

They are round in shape and are worked on the down draft principle and are similar to a brick or potting oven. They are fired with a mixture of coke and coal, and considering that no regenerative or continuous process is used in conjunction with them they are economical in fuel. At the Universal Co's works there are 19 of them, the largest holding about 14 tons of wheels. The wheels are packed in sand in built up fireclay

Shaping Room for Small Wheels

boxes arranged in rings similar to a pottery oven. The firing lasts from 70 to 100 hours, according to the size of the kiln. After firing the kiln is sealed up, and if there are big wheels inside, the cooling has to be as slow as possible. In some cases as much as three weeks elapses before the kiln can be opened. The firing is the most delicate of all the processes, and it is here, if the utmost precautions are not taken, that losses can occur. Not only must the rate of heating up and cooling down and the evenness of temperature be accurate, but also the nature of the products of combustion must be just what is required. The wheels on being taken from the kiln have the loosely adhering sand rubbed off, are checked and inspected, every wheel being held up and rung with a hammer, before being passed on to the next stage, from which the majority of the wheels go to the trueing up shop. This trueing is more of an engineering job than any other in the factory. The machines in this shop are all of the Company's own design, and are made in their own tool room. The wheel to be trued up is mounted on a face plate of a bedless lathe, which face plate is mounted on a head stock, running on special dust proof bearings. Before fitting these special bearings, rebushing was necessary about every three weeks. It will be understood that in spite of dust extraction plant there must be, and there is, abrasive dust everywhere. Abrasive dust and moving machinery do not agree. Now it is possible to run the machines at least two years without adjustment. The cutting or dressing tool is mounted on an upsidedown compound slide. By having this slide upsidedown ensures that the thread of the traverse is always covered up, and this relieves the wear caused by the abrasive dust. The lathe headstock and the last mentioned compound slide are mounted on separate box castings. The cutting tool itself has been the subject of many experiments and the company now have a satisfactory tool. It consists essentially of a cone shaped cutter about $2\frac{1}{2}$ in. diameter made of special steel produced by Jessop's. This cutter is mounted on a steel spindle $\frac{3}{4}$ in. diameter, which revolves on double thrust ball bearings carried in a dust proof iron box. The operation of trueing up is as follows. The wheel to be trued up is mounted on the face plate on a self centreing chuck. It is revolved on the above described cutter, and this is traversed across the face of wheel, and being free to move the cutter revolves at a high speed, being caused to do so by the revolving grinding wheel, with which it is brought in contact. The cutter is set to meet the wheel at an angle of about 15 degrees, and a cut can be taken up to $\frac{1}{4}$ in. The wheel is similarly trued up on its periphery, but for this portion of the operation is mounted on a mandrill. On the same machine large holes are bored out and recesses are cut, taper cut wheels, etc., being trued up all over. For some operations diamonds have to be used, but naturally the company limit the use of diamonds as much as possible. They have to be used, however, for the finishing of the cutting faces for dishes, etc., and for finishing gauge grinding wheels, and special wheels made for cutting glass. Not all the wheels are trued up, it being possible to finish completely some wheels in the earlier shaping processes. The Universal Co. are always trying to extend the varieties of wheels which can be finished in this way owing to the saving in cost. One of the difficulties, however, that they have to overcome is the liability that these articles have to warping in the kiln.

After leaving the trueing shop the wheels that have to be lead bushed, are placed in a self centreing chuck, in the centre of which is a spindle of approximate diameter 5000th's bigger than the required hole. Lead is then poured round this to fill up the space between such spindle and the edge of the hole in the wheel. There is a diversity of opinion among grinding wheel users as to whether the hole in the wheel is better leaded or not leaded.

Testing

Generally, however, the more usual practice is to lead holes of under 5in. and not lead holes of over 5 in. After leading, every wheel over 5 in. in diameter is given a special safety test. This safety test consists of mounting it on a spindle inside a mild steel casing, and revolving it at a speed of at least 9,000 surface feet per minute for two minutes. This gives a considerable safety factor, because the grinding speed of the wheel is from 4,000 to 6,000 feet.

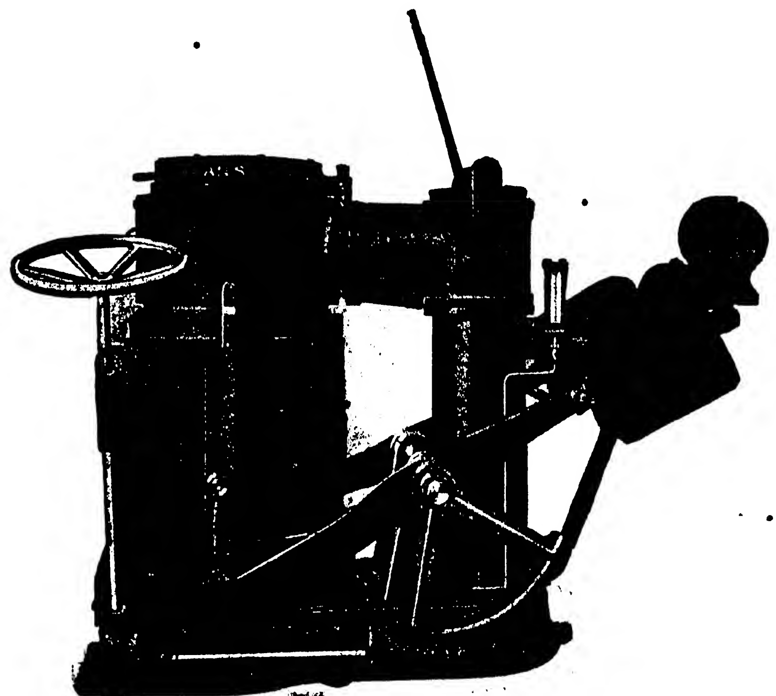
As a matter of fact grinding wheels made by the method described will stand a much higher speed and the company frequently test them at anything up to 16,000 ft., as the testing machine happens to be set. It may be taken to-day as almost certain that if a grinding wheel made by a reputable firm breaks in use there is some other cause for it than in the construction of the wheel. The most common cause for a breakage is the getting of the tool that is to be ground caught between the rest and the wheel.

(*Continued on page* 267.)

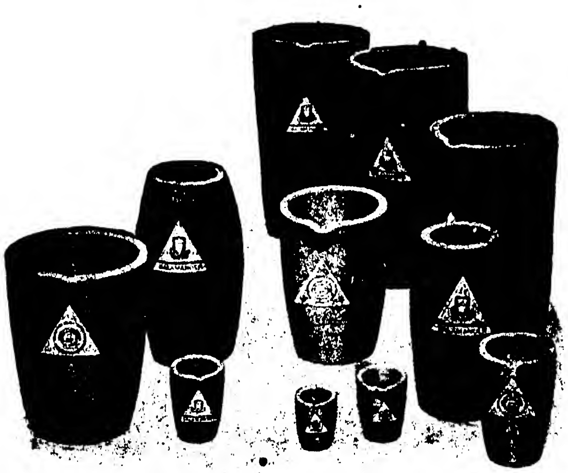
Notable Exhibits at the International Foundry Trades' Exhibition, Birmingham

ORGANISED by the Birmingham Chamber of Commerce, in conjunction with the Institution of British Foundrymen and the British Cast Iron Research Association, the recent exhibition of foundry appliances and products proved an unqualified success. The exhibits covered the whole range of foundry work. Moulding machines from the simplest type to those of great size and complexity, were naturally very much in evidence, whilst cupolas, ladles, riddling machines, sand mixers, pattern and pattern making machinery, castings, grinding machines, crucibles, fire bricks, pig-iron, and all the other necessary appliances and materials were well displayed.

The Morgan Crucible Co. Ltd. exhibited a new range of crucibles, for which they claim definite melting economies. A crucible of 2,000 lb. capacity sheltering its offspring, the capacity of which is only a few ounces, demonstrated the excellent variety of sizes in which these crucibles are produced. As is well known, the cost of crucible melting depends on the amount of fuel consumed, the rate of melting, and the life of the crucible, but a new process has rendered it possible for Morgans to produce a crucible which will melt a given charge of metal in 20 per cent. less time, with 20 per cent. less fuel and 20 per cent. longer life than the standard crucible employed to-day.



Morgan Patent Tilting Furnace. Type A



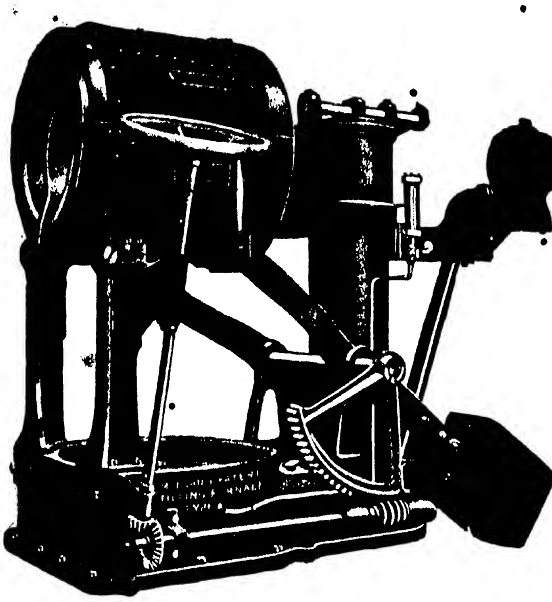
A new range of Morgan Crucibles

This is illustrated by two crucibles marked respectively " A " and " B."

In pot " A " it is possible to melt 160 lb. of brass with 40 lb. coke in one hour.

In pot " B " (the crucible of yesterday), 50 lb. coke and 1¼ hours are required for the same quantity and type of metal.

Among the many other interesting exhibits on this stand is a series of hot plates, called " resisters," which can be maintained at any desired temperature up to 1,350 deg. C. They are of refractory material, with a glazed surface, those shown being about 2 ft. long by 1 ft. wide, and about an inch thick. A ziz-zag layer of carbon is incorporated in the surface, and is fitted with terminals into which a flexible electric conductor can be plugged. The temperature of the plates is perfectly uniform except round the extreme edges, and of course remains unchanged so long as the current is kept on. For temperatures below a red heat the life of these " resisters " is said to be indefinite, and even at much higher temperatures it is very long, as there is no possibility of the carbonaceous layer becoming detached from the base. For household and laboratory purposes they have numerous obvious uses, and they should find a large field for employment in the manufacture of ovens, furnaces and other apparatus, as they seem thoroughly sound mechanical devices. The Morgan Crucible Company also show one of their well-known tilting furnaces, as well as an electric furnace for non-ferrous metals. In this the current flows through re-



Another view of the Morgan Patent Type A Tilting Furnace

is of the multi-blade type, constructed of sheet steel and balanced on a ground mild steel shaft running on ball bearings carried in dust-proof housings, and lubrication by grease cups. The machine exhibited is arranged for belt drive, but can be readily adapted for direct motor drive. In the case of the smaller motor-driven machines, the motor is carried on a substantial cast-iron stool, and the fan runner mounted on the end of the motor shaft; for the larger sizes the drive is effected through a rubber-bushed flexible coupling.

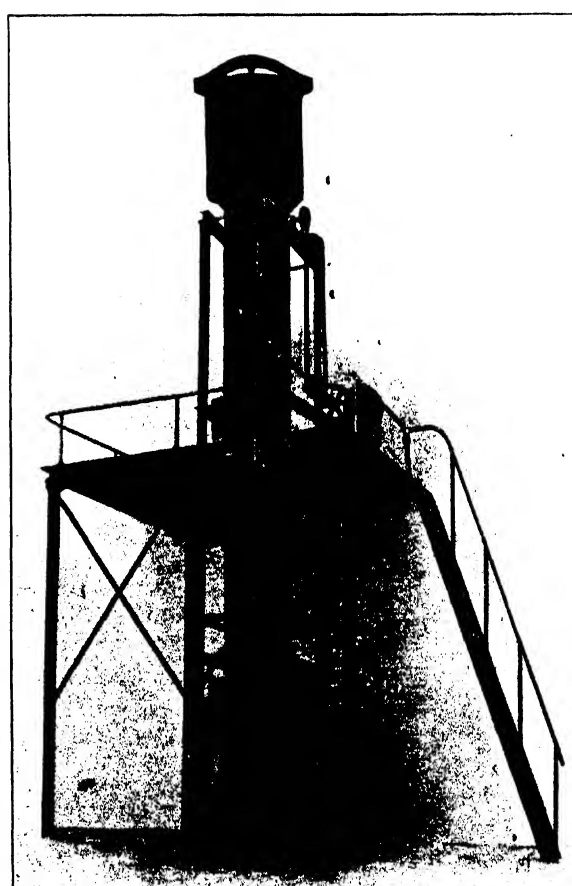
Alternatively, a Roots blower can be used for supplying the blast required by the cupola. The cylinder is constructed of cast-iron, ribbed where necessary. The flanges, revolvers, etc., are all carefully machined, and the gear wheels machine cut from solid blanks. The cast-iron covers in which these gears are encased form an oil bath. Particular attention has been paid to the bearings, which are in the form of heavy gun-metal sleeves of the cone type, with an adjusting nut for taking up wear. These machines can be adapted for drive by electric motor or steam engine. In that case the bedplate is extended to carry the motor or engine, and the drive effected through reducing gear or coupling, as required.

The sand mill is strongly made of

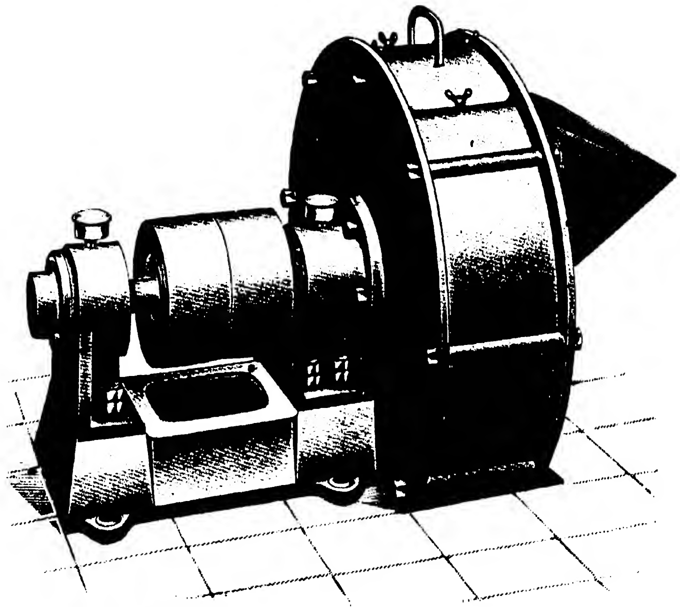
sistances material incorporated in the walls of the furnace, the electrodes being heavy bronze rings surrounding the furnace at the top and bottom.

Messrs Alldays & Onions Ltd. were making a special feature of their improved "Climax" rapid cupola, capable of melting from one to two tons of metal per hour, fitted with spark arrester and drop bottom, complete with staging and hand-operated hoist. A feature of this exhibit is its substantial construction, the cupola shell being built of mild steel plates riveted together with lap joints. Care has also been taken in strengthening the bottom ring, charge hole, and fettling hole. A hinged steel door is fitted to the charge hole; the fettling hole provided with loose mild steel door having cross bar and fittings. The air bolt is of ample dimensions, fitted with the usual elbow pipes and wing valves for blast. Opposite each tuyere, mica sight hole and door are provided. The tuyeres are bolted to the inside of the shell, thus excluding the possibility of blast leakage between the lining and the shell. The cupola is carried on heavy cast-iron pillars. The drop bottom consists of hinged doors provided with draw-bar and fittings. A receiver, connected to the shell by an iron casting lined with firebrick, can be fitted if required.

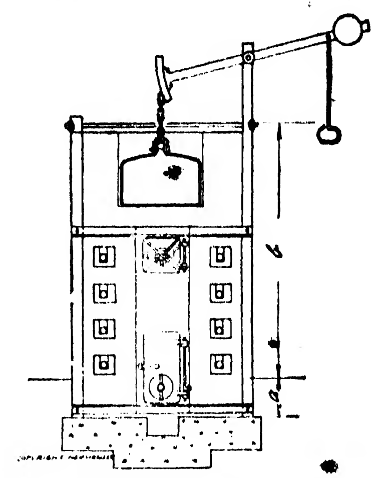
The fan recommended for use with the above cupola is Messrs. Alldays & Onions' well-known and highly efficient Duplex fan. It is built of substantial cast-iron volute casing, with all joints machined. The fan runner



Alldays & Onions Improved rapid Cupola



Alldays & Onions Empire Sand Mixer and Disintegrator



The Hermansen new type of light Forging Furnace

cast iron, fitted with fast and loose pulleys, self-delivering fixed pan, and is actuated through gearing underneath the pan. The bearings are of generous proportions, and special attention has been given to the rolls and other wearing parts.

The steel shaking or tumbling barrel exhibited is especially suitable for cleaning light castings. It is constructed in ⅜ in. steel plates, welded, provided with open and close lid and fasteners, trunnions, and is mounted upon cast-iron A standards. Equipment includes fast and loose pulleys.

Specimens of Alldays & Onions' world-famous moulders' bellows, fitted with valve protectors and ordinary or neats leather, are on the stand, and maintain their foremost position for quality.

The remaining items on Alldays & Onions' stand comprise a double-cased, gas-fired core oven constructed of steel sheets and channels, packed throughout with a 2 in. thickness of non-conducting material, and provided with a pair of double-cased hinged doors. Ovens of the single-cased or treble-cased types, either solid fuel fired or oil-fired, can be supplied.

The firm also have on exhibition ladles, single and double-handled, and for use with a crane.

The Hermansen Patent Recuperative Furnaces were a continual source of attraction, and it was reported that excellent business was being done. The new type of light forging furnace, designed on the semi-gas fired recuperative principle, as illustration, was the chief exhibit, as to put down a crucible furnace would have necessitated excavating the ground floor of the exhibition.

The following table gives a comparison of fuel costs of this furnace, compared with those mostly in use in England :—

Town gas furnace : 4,000 cu. ft. (low figure) at 4/- 1,000 cu. ft., 16/-.

Open forge : ½ ton foundry coke at 50/- per ton, 25/-.

Ordinary oil-fired furnace : 12½ per cent. of weight of fuel oil, at £5 per ton delivered, 12/6.

" Hermansen " recuperative furnace : 2 cwt. coal at 30/- per ton, 3/-.

These figures speak for themselves, and are a feature which no doubt engineering works will appreciate when they get acquainted with them.

This forging furnace is of quite recent design, and, as can be readily seen, a small gas producer is arranged in the centre, with recuperator on either side. An excellent feature is that it can be started up from lukewarm in about twenty minutes.

Hermansen Forging Furnace installed in Scandinavian Works

The "Hermansen" forging furnace shown in the illustration was installed in a Scandinavian works, and has proved so satisfactory that the firm has ordered five more.

In this particular case the furnace is actually run on wood shavings, with which a sufficiently high temperature may be obtained for drop forgings. With a small modification, the same

furnace can be altered to a closed muffle for annealing and tempering.

Messrs. Hermansen also supply various types of melting furnaces, core ovens, and malleable iron annealing furnaces.

The Constructional Engineering Co., in addition to making an excellent display on their stand, were called upon by the Exhibition authorities to equip their modern foundry. The No. 3 cupola has a melting capacity of 2 to 3 tons of metal per hour, complete with spark arrester, staging (12 ft. by 10 ft.), and direct coupled fan and motor, and electric hoist operated by electric winch. This plant is complete, and self-contained, and carries Wood's patent improvements.

Considerable interest was centred on a Wood's patent belted cupolette, with a melting capacity of 35 cwt. of metal per hour, and suitable for grey iron, malleable iron, or semi-steel. The cupolette is fitted with direct-coupled fan and motor, mounted in staging, and complete with hoist operated by winch of special design.

The hydraulic pig iron breaker, fitted with hand-operated pump, is suitable for breaking any grade of pig iron, and, being a small and inexpensive plant, must effect economy in any foundry. Amongst the show of ladles, the 20 cwt. capacity steel bottom pouring ladle, with patent pressed steel bow, and improved gearing and bottom pouring arrangement, calls for special commendation. We were also interested in the new pressure volume indicator, which is absolutely efficient for indicating the volume and pressure of blast supply.

Messrs. Wadkin & Co. were demonstrating their well-known pattern-making machine, and had a most representative exhibit of wood-working machinery for the pattern shop. The pattern-maker's lathe has a particularly useful feature, as the spindle extends behind the headstock, thus enabling the work to be turned at the end of the lathe, which could not be carried over the bed. The latest design of surfacing and thicknessing machine was a continual source of interest. The surfacing table is 6 ft. 1 in. long overall, and, as it is scraped dead true, it is possible to make perfect glued joints, in spite of the very large surface. The machine will surface 26 inches wide. The thicknessing table is 3 ft. 9 in. long, and is fitted with anti-friction rollers and carrying rollers for long work. It can be raised and lowered 9 inches by means of a hand wheel. The cutter block is of the two-knife safety circular type, and can be fitted with either plain or moulding cutters. The power-feed rollers are of steel, and driven by a heavy sprocket chain. This permits the rise and fall of the rollers, due to the different thicknesses of cut. Three rates of feed are provided, *i.e.*, 40 ft., 30 ft., and 20 ft. per minute, and the operator can change the speed by giving a partial turn to the hand wheel in front of the machine. Rebating, moulding, tongueing and grooving, bevelling and mitreing, shaping newels and panel raising, all come within the capacity of this machine, thus rendering it almost indispensable in the wood-workers' shop.

Reviews

ELECTRO-DEPOSITION OF IRON—By W. E. Hughes, B.A., (Cantab.) The Department of Scientific and Industrial Research Bulletin, No. 6. Post free. Price 6s. 8½d., to be obtained from H.M. Stationery Office, Imperial House, Kingsway, London, W.C.2.

This volume which is profusely illustrated with micro-photographs of the deposits, resulting from a very large number of experiments made under different conditions, embodies the research work of Mr. Hughes, and the contents are well illustrated by the following extracts from the introduction of the Bulletin.

This report includes, as Division I, simple descriptions of the structures of a number of samples of iron, electro-deposited from the chloride of iron solution. The purpose is to show how the three factors of deposition, namely, (1) temperature; (2) current density; and (3) movement (of cathode or electrolyte), affect the structure of the iron deposited from the chloride bath. Incidentally, the micrographs disclose variations of structure produced by volume of solution concentration currents and some other factors.

Although the deposits considered were formed in the chloride of iron solution, there is, it may be said, experimental evidence to show that the conclusions drawn from the structures of deposits built up in that bath may be extended to those formed in other solutions. This point is touched on in Division II, and, further, some evidence is adduced there to show that extension may be made not only to deposits formed in different solutions (solutions of different salts, that is), of the same metal, but also to deposits of different metals. Indeed, a principal purpose of Division II., is to show that, in general, this is the rational conclusion of the concentration hypothesis outlined in that Division, and based on the assumption that the crystallisation of electro-deposited metal is, essentially, in no way different from crystallisation from rock magmas, molten metals, or salt solutions. In section III. of Division II., the importance of the study of the structure of deposited metal to electro-deposition in the workship is briefly pointed out.

It may be mentioned that the author has made a critical survey of such part of the literature upon the electro-deposition of iron as appears to him of use or importance to those about to undertake work on that subject. It has, however, been considered that that review would be published most appropiately elsewhere, and it has not, therefore, been included in this report. The papers and researches referred to are, however, detailed (in an Appendix in this Bulletin), together with others on the properties of electrolytic iron, in a classification intended to indicate the general subject matter of each, and, thereby, to facilitate the literary labour required to be done by one who undertakes research, for this purpose or that, on electrolytic iron. Patent specifications are, for the most part, excluded; only such as appear to the author to contain subject matter of real value are noted.

ORGANISATION

Conducted by HARTLAND SEYMOUR

THIS SECTION DEALS WITH WORKS MANAGEMENT AND ORGANISATION, THE TRAINING AND WELFARE OF THE WORKERS, AND WITH THE ADVERTISING, SELLING AND MARKETING OF GOODS

Welfare Superintendents and their Training

By GLADYS M. BROUGHTON

Adviser to the Government of India, Department of Industries

THE necessity of improving the conditions of employment is generally recognised throughout the civilised world to-day. Not only are the various countries each engaged in considering measures for ameliorating the lot of their workers, but the subject forms the agenda of the annual International Labour Conferences of the League of Nations. Members of that organisation are required to endeavour to secure and maintain fair and humane conditions of labour for men, women and children not only in their own country, but also in all countries to which their commercial and industrial relations extend. Each country is now no longer left to work out its own salvation in solitary isolation, but has to share its experience, its aims and aspirations, with others. Thus measures that have been found useful in one country are made public, so that other countries may adopt them to their own requirements. The welfare movement may be regarded both as an expression of the justice of this claim on the part of labour to be accorded fair and humane treatment, and as an attempt to achieve this end. This movement embraces many diverse activities, but in this paper I shall deal only with the subject of welfare superintendents, the work that might be entrusted to them in the factory, and the training needed to enable them to undertake such responsibilities.

All enlightened employers recognise their responsibility for the well-being of their employees during working hours. They endeavour to supply good working conditions, reasonable wages, and insist upon the workers being treated with consideration and justice. As it is not possible, however, for an employer to undertake all these duties himself, he must necessarily allocate them among the various members of his staff. Where factories are large, it is customary to make one official chiefly responsible for supplying the personal touch between the workers and the management. Such a person is sometimes called a welfare superintendent or an employment supervisor. He is frequently given the duty of engaging all the employees, and of keeping all personal records relating to them. After a man has been engaged, the welfare superintendent is kept informed of the progress made by the employee, and if he has selected an unsuitable man he has the duty of dismissing him. In this way he or she gradually acquires a good working knowledge of the type of man or woman who is likely to be satisfactory in the different branches of the work. It also enables him to smooth over the initial difficulties that are bound to arise when a new employee enters as a stranger into a large organisation.

Besides thus getting a knowledge of the working conditions, the welfare superintendent is frequently made responsible for seeing that the provision made for meals and for drinking water is satisfactory. In some mills in India separate sheds are erected outside the works, where employees can enjoy their midday meal and rest away from the noise and dirt of the factory. Various details have to be dealt with in connection with such a place. Employees may be glad to have facilities for buying fruit and sweets, etc.; they will want to observe their caste rules while having their meals; they will need provision for washing before and after eating. All such matters will necessarily be brought before a welfare superintendent. He will either deal with them direct or refer them to the management, where expenditure is involved. Similarly with regard to drinking water, the various castes will have to be dealt with sympathetically, and their requirements for separate arrangements supplied.

The supervision of the general sanitary conditions of the factory also usually falls to the lot of a welfare supervisor, and in most factories he can do a great deal to improve the sanitary arrangements, and to see that the health of employees is not injured by being required to work in unswept and dirty places.

Again, as in most factories accidents are liable to occur, an employment superintendent will bring to the notice of the management the need of a dispensary and proper equipment. In large factories in India, one frequently finds that not only is there a dispensary, but that it is in charge of a qualified medical man. Where women are employed, it is desirable to have a medical woman to attend to them. A few factories have appointed a woman doctor for this purpose, and much benefit has resulted.

Time-keeping is often a subject requiring much attention. Employees do not always realise how their work is an integral part of the entire work of a factory, and how the absence of even one man sometimes throws the whole machine out of gear. If this were explained to them in a proper manner, they would probably not

stay away so frequently for trivial reasons. Or again, the workers may be confronted with difficulties which it is not possible for them to overcome unaided by the factory authorities. Thus, for instance, transit facilities may be quite inadequate. If the employment superintendent makes a study of this question, he may frequently be able to offer valuable suggestions to the management. He may find that in certain departments the time-keeping is much worse than in others. This may lead to an enquiry into the working conditions, and the cause of bad time-keeping may be found to arise from the unhealthy nature of the work or from excessive overtime, or from some other cause which may be quite unknown to the management, but which, when known, may easily be removed. Or again, the men may not always understand how their wages have been calculated, or there may be some fault in the machine which prevents them from earning as much as possible. They can discuss these matters with their welfare superintendent, who will bring them to the notice of the persons concerned.

It is, of course, desirable that the employees should themselves be in a position to bring their wishes and suggestions and grievances to the notice of the management, but in the majority of factories they can only do so by forcible methods, such as a strike. Where works committees are organised, the employees have a direct method of access. The welfare superintendent is, in such cases, a member of the committee, and may even act as secretary. He can teach the members how such a committee should be run, and can frequently get them to lay aside minor grievances, and can explain away many misunderstandings.

The Manager

The ultimate responsibility for the work in a factory, however, rests with the manager. In large factories he may depute some of his duties to one or more officials, but he must always be the man to whom all will look for inspiration, and to whom the ultimate appeal will be made. It is true that the manager himself frequently cannot decide big questions of policy, and cannot authorise heavy expenditure. But if he is sympathetic and succeeds in keeping a contented labour force under him, his suggestions and recommendations for ameliorative measures will be accepted by the firm.

The various measures by which good conditions of employment may be secured are briefly as follows :—

(1) The employees should be given an opportunity of bringing their suggestions before some responsible official.

(2) This official must have a place on the management, and should carry sufficient weight for his recommendations to be accepted wherever possible.

(3) The manager should realise that one of his important functions is to secure and to keep contented workers.

(4) The firm or company must be ready to regard sympathetically proposals made for the welfare of the employees, and must be prepared to sanction expenditure towards this end.

Training

This extensive list of duties, which, it is suggested, ought to be undertaken by a welfare superintendent, is in itself sufficient proof that such work cannot be entrusted to amateurs. The manager will require a person who has been trained in this work before he can appoint him as his deputy. As far as I know, however, no facilities for such training exist in India. But even if this training could be obtained, it would not be possible to get candidates unless there were reasonable prospects of employment at the end of it. The first step, then, is to convince employers of the benefits that would result if such appointments were made, and in that way to create a demand for persons capable of doing that form of work.

Assuming that such a demand does gradually arise, I will next consider the kind of experience that will be found to be most advantageous by those who wish to secure such appointments. The first essential is a knowledge of the classes that compose a factory. Such knowledge can be acquired in various ways. There are now agencies in most large industrial towns which undertake to look after the needs of workers outside the factories. It will be necessary to become an active member of such an organisation, and to undertake definite duties. Thus, for instance, it may be possible to help with educational evening classes, or, if one has medical qualifications, to supply medical aid and advice, by doing voluntary work at an infant welfare centre. Or, if one has had business training, the establishment of co-operative stores and saving banks may be instituted. The Social Service League, the Servants of India Society, and the All-India League for Maternity and Child Welfare, the various infant welfare centres, may be mentioned as some of the societies who would be willing to accept the services of voluntary workers.

These different forms of social service should bring one into intimate contact with industrial workers, and thus it will be possible to secure some knowledge of their mode of life and the difficulties with which they have to contend. It should be possible, also, to get this experience during leisure hours, but in order to become qualified to do welfare work inside a factory, much more will be necessary. To do this, a knowledge of factory conditions is essential. To gain this experience, I have heard of persons entering a factory as ordinary employees. For many, however, this would not be possible, and may give rise to suspicion among the workers. A better way is to secure a post of some responsibility on a factory staff. There will be little difficulty for those who have medical qualifications. Those, however, who are not so fortunate, may get some clerical appointment in the works, and may ask to be entrusted with the duty of improving the time-keeping or of interviewing applicants for engagement, and of seeing all who leave, and keeping the necessary records. The attempt should be made to get a post which will bring the would-be welfare workers into direct contact with the workers, and which will enable him, at the same time, to render useful service both to them and to the management. Having secured some such position in the works, the next step should be to join, if possible, a University course of lectures on economics. It is essential to know about different wage systems and the laws governing supply and demand. A knowledge of factory legislation is also necessary. The growth and functions of trade unions in different countries should also be studied. If lectures cannot be attended, standard works on economics should be purchased and studied.

Students of economics in Universities may, too, fit themselves for undertaking welfare work in factories.

(*Continued on page* 291.)

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE :: :: :: :: DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS :: :: :: ::

The Restoration of Oil Efficiency

Modern Methods of Filtration

ONE phase of engineering operations in which rapid strides have been made during the past few years is that of the lubrication of machinery. Not many years back machinery was lubricated, it is true, but as yet little effort had been made to bring scientific study to bear on lubrication and all its problems.

Simultaneous with this advance in the study of lubrication have been the developments and inventions for the recovery of used oils and their restoration to 100 per cent. efficiency.

It was found that one of the greatest sources of waste in lubrication could be eliminated. It was proved that oil does not wear out, but simply becomes contaminated with dirt, metal particles, carbon or water, and that all that was necessary was to produce a proper commercial method of filtration and purification. This was done, making it possible to use the same oil over and over again, with but small actual loss.

To prove that there is no foundation for the belief that oil "wears out," the Richardson-Phœnix Company, of Milwaukee, pioneers in oil filtration, had some tests made at the laboratories of Cornell University on oil taken from one of their central oiling and filtering systems in a prominent power plant where the conditions are very severe.

On account of the great variety of machines lubricated, the high load factor and the exceptional conditions, the work imposed on this lubricating system is probably as severe as can be found anywhere. At the time the samples were obtained, the system had been in operation for over a year and a half, and the question naturally arises, what physical changes, if any, did the oil undergo during this extended period ?

To determine the changes undergone by the oil, a sample of new oil was tested, and also a sample of oil drawn from the clean oil compartment of the filters. A series of friction tests were made on a Thurston railway lubricant tester. The testing machine was run at a constant speed of about 360 r.p.m., and the load applied in increments of 75 lb. pressure per square inch. The test at each load was continued until the friction and temperature of the bearings had become constant.

The results of the friction tests are shown in Fig. 1. The curves show that at working pressures the filtered oil is as good as new oil. It will be noted that the two temperature curves in Fig. 2 are practically superimposed, and in no case is the variation more than a few degrees, giving ample proof that the lubricating quality of the filtered oil is practically unimpaired.

Tests of the new and filtered oil were also made in an Olsen viscosimeter. The results of these tests are shown in Fig. 3. The viscosity curves show that as oil is used over and over again in an oiling system, it actually gains in body, provided a filter is used which thoroughly removes dirt and entrained water.

The results of tests of the physical qualities of the new and filtered oil were as follows :—

SAMPLE "A." NEW OIL.

Colour—medium red, translucent.
Flash point—410 deg. (open cup).
Burning point—460 deg. F. (open cup).
Specific gravity at 60 deg. F. water as 1, .895.

SAMPLE "B."

PURIFIED OIL FROM AN R-P FILTER.
Colour—very dark red, opaque.
Flash point—410 deg. F. (open cup).
Burning point—440 deg. F. (open cup).
Specific gravity at 60 deg. F. water as 1, .903.

The Richardson-Phœnix type "A" oil filter operates on the so-called dry principle of filtration, in which the oil is not passed through water. It is designed in accordance with the latest engineering practice, and embodies all the essential features necessary for scientific oil purification.

The process of purification is accomplished both by precipitation and by filtration through closely-woven cloth. By the former process, the oil is brought practically to rest, and entrained water and heavy particles of foreign matter are allowed to settle out. The capacity of an oil filter really depends on its ability to precipitate entrained water from the oil. This water, which is always present to a more or less degree in plants operating steam engines, pumps, etc., comes from slight leakages around piston rod stuffing boxes, etc. Therefore special attention has been given to making the precipitation compartment of this filter as large as possible, and of a highly efficient design.

Briefly, the operation of the Richardson-Phœnix power plant oil filter is as follows :—

(1) The incoming dirty oil is heated to lower its viscosity, and thus reduces its ability to retain water and solid particles in suspension.
(2) The oil then takes a long path, flowing at a low velocity over shallow trays, where precipitation takes place.
(3) The oil then flows through the filtering medium, every square inch of which is effective, and subject to equal pressure.
(4) The oil is stored in the clean oil compartment ready for re-use.
(5) When necessary, the oil is passed over cooling coils after it has been filtered.

The following detailed description of the operation of the filter shows why it purifies oil so efficiently. Referring to Fig. 4, the dirty oil

enters the filter through the removable strainer box (1), (2), where large particles of foreign matter, such as waste, etc., are removed. The oil then passes to the heating tray (3), where its viscosity is so reduced that it becomes extremely thin, and is unable to retain water and solid matter in suspension. The value of heating the oil is evident by referring to the viscosity curves in Fig. 3. For instance, oil "B" at 70 degrees, is practically five times as viscous as water, and thus it would take entrained water a long time to settle out. However, if this same oil is heated to 140 degrees, it is only one and one-half times as viscous as water, and will offer very little resistance to water settling out.

The heating tray is so arranged that the oil flows over the heating coil (4) in a thin sheet, so that every drop of oil is brought into intimate contact with the heating coil. Steam is generally used, but heating elements for utilising hot water or electricity can be furnished when desired.

After passing over the heating tray the oil flows to compartment (3) and down through funnel (6). Passing down through conductor (7), the oil is spread out by baffle (8) under the bottom of tray (9). Under the action of the greater head which can build up in conductor (7), the oil is forced to take a zig-zag path upward, passing under and over trays (9), (10), (11) and (12), as shown by the lines of flow. The oil then passes out through opening (14) to the filtering compartment. The four precipitation trays are made of galvanized sheet steel, supported on suitable legs, and fit snugly into the precipitation compartment, except for openings on alternate ends; the trays are provided with handles, and can easily be lifted out for cleaning when necessary.

Having reduced the viscosity of the oil by heating it, if we could spread it in a very thin sheet, water and heavy particles would settle out almost instantaneously. Of course, in a commercial filter it is impossible to spread the oil out in a single thin layer, on account of the limitation of floor space; however, in this filter the same effect is secured by using a number of trays. As the oil passes over the trays at a very low velocity (7/10 feet per minute at the normal rated capacity of the filter), the heavy particles of dirt and water settle at the bottom of these trays. As the water, in settling out of the oil, takes a course at right angles to the direction of the flow of the oil, the movement of the oil offers no resistance to the precipitation process. Any solid matter which is precipitated out collects in the bottom of the trays, and as the oil flows over the trays at such a low velocity, and as the sediment is out of the direct course of the oil, there is no danger of its being picked up again. As the trays are deep, they will hold a large quantity of sediment, thus rendering frequent cleaning unnecessary.

The separated water collects in the bottom of the different trays, and is by-passed directly to the bottom of the precipitation compartment by means of funnels (15), (16), (17) and (18), and does not have to come in contact with the travelling oil, where it might be picked up again.

The water in the bottom of the precipitation compartment is automatically ejected by the adjustable water overflow tube (19). This water overflow is simply a U-tube; that is, the column of water in pipe (19) balances a column in the precipitation compartment, which is made up largely of oil and partly of water. As oil is lighter than water, the top of the tube (20) is a little lower than the overflow level of oil in the precipitation compartment. It is evident that as more water is precipitated out of the oil, and the water level in the bottom of the precipitation compartment tends to rise, that one leg of the U-tube becomes overbalanced, because it is made up of a greater proportion of water and less of oil; thus water flows over the top of nipple (20) and out through opening (21) until the two legs of the U-tube again balance, thus maintaining the proper level in the precipitation compartment.

The overflow is always water sealed, and can be so adjusted that even the heaviest oil will not pass out through it.

The level of the oil in the top tray is maintained constant by the skimmer (13). The oil then flows through pipe (14) into the filtering compartment (22), which contains nine non-collapsible filtering units. Each unit consists of two 12 in. × 18 in. sheets of heavy galvanized wire screen, separated one inch and held in a suitable metal frame. The edges are smooth, so that the filtering bags can be easily slid on and off. The cloth is in the form of a bag, and is held over the screens by means of a cover and two thumb nuts. These thumb nuts are flanged, so that they do not become detached from the filter unit cover. The cloth is brought up over the top of the filter unit, and when the cover is screened down, is held tightly in place. This method of attaching the filtering cloth provides for its easy removal for cleaning purposes, and is such that the oil in passing through the filtering units must go through the cloth. The oil passes from the outside to the inside of the filtering units, then out through the nozzles (25), which project through the wall of the filtering compartment, to the clean oil compartment. The nozzle on each filtering unit fits into a spring actuated valve, so that any individual unit can be withdrawn and cleaned without interfering with the continuous operation of the filter. When the filtering unit is withdrawn, this valve instantly closes, and pre-

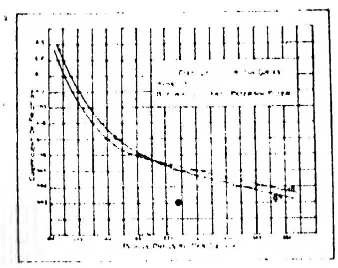


Fig. 1

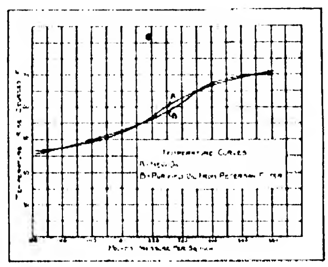


Fig. 2

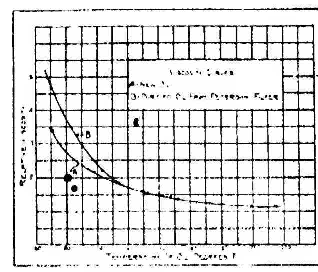


Fig. 3

vents unfiltered oil from flowing into the clean oil compartment.

The clean oil occupies all of the space in the bottom of the filter under the precipitation and filtration compartments, and also the space alongside of the filtering compartment, which is about one-half as wide as the filter. The clean oil is piped off through a fitting in the centre of the bottom of the filter.

In the design of this filter more attention has been given to the scientific distribution of the filtering cloth than to the quantity employed. The cloth is so arranged that it is free from folds or plaits, thus rendering every square inch active in filtering. Whenever filtering cloth is wadded up or gathered so that the folds occur, the cloth, in some places, presents a single thickness, and in others a triple thickness in the oil circuit. When this condition exists, it is evident that the oil will follow the path of least resistance, and practically all of the oil will pass through the single thickness portions, and those portions having more than one thickness will be rendered ineffective.

In the Richardson-Phœnix filter, no oil can pass to the clean oil compartment until the level in the filtering compartment (22) reaches the outlets (25), thus no filtering takes place until every square inch of the cloth is submerged in oil. As soon as a slight head builds up over the outlet, the process of filtration commences, and is equally distributed over every square inch of surface.

The rate at which filtration takes place depends upon the head over the filtering units, this head automatically adjusting itself to the rate at which the filter is being worked. The filtering units operate on the U-tube principle. It is evident that if there is a head "A" of three inches over the outlet, at any point "X" on the filtering surface, there is a difference of head of three inches between the oil on the outside of the filtering cloth and that on the inside. No matter where we take the point "X," the head "B" is always the same on the outside and on the inside of the bag, and these two columns always exactly balance each other. Therefore, the net head acting on the outside of the cloth is always "A"; thus there is absolutely the same difference in pressure between the two sides of the cloth all over the filtering surface, and the process of filtration is uniformly distributed.

The head of oil over the filtering units is shown by the indicator at the top of gauge (23). When the filter is being operated at normal rating, this gauge should show a level of about three inches. If a greater height is indicated, it shows that the oil is not passing through the cloth as fast as it should, and therefore the cloths need cleaning. The filters are rated at a 3-inch head over the filtering units, but space is provided for carrying a 6-inch head. Thus the filter is capable of handling short overloads of 100 per cent., so that in case a large batch of oil should be run in, the filter will be able to take care of it. However, like all other power plant machinery, when run at over rated capacity, the efficiency of the filter is somewhat decreased, that is, we have found that a 3-inch head of oil gives a rate of flow consistent with thorough filtration, but

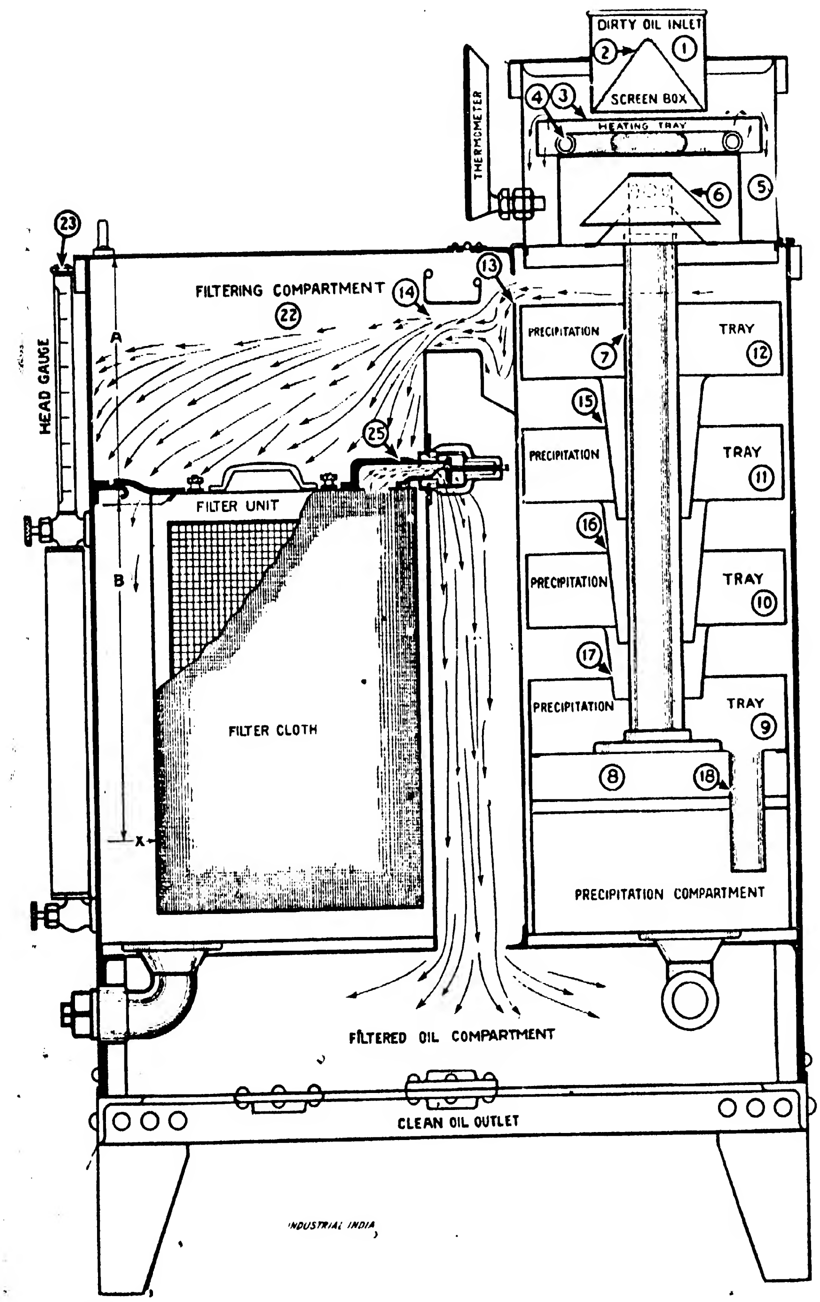


Fig. 4

if the oil is forced through the cloth at a greater rate, purification will not be so complete. The provision for a head greater than 3 inches also permits of running the filter at the normal rate after the cloths have become foul, that is, when the cloths are dirty the same rate of filtration can be maintained by carrying, say, a 4-inch or 5-inch head of oil over the filter units, instead of the normal head of 3 inches. This allows considerable latitude as to when the cloths should be cleaned.

The capacity of the filter could be greatly increased by carrying a head of two or three feet over the filtering units, but a head as high as this is liable to cause the very fine particles of dirt to be forced through the filtering medium along with the oil, thus lowering the efficiency of the filter.

There is a decided advantage in arranging the filtering cloth in a vertical position, and having the oil pass from the outside to the inside of the units, because the slime and sediment which collects on the outside of the cloth continually works towards the bottom and drops off, thus automatically tending to keep the surface clean. When cloth is arranged horizontally, the sediment forms a cake on top of the cloth, greatly slowing up the process of filtration, and necessitating using several times as much filtering surface.

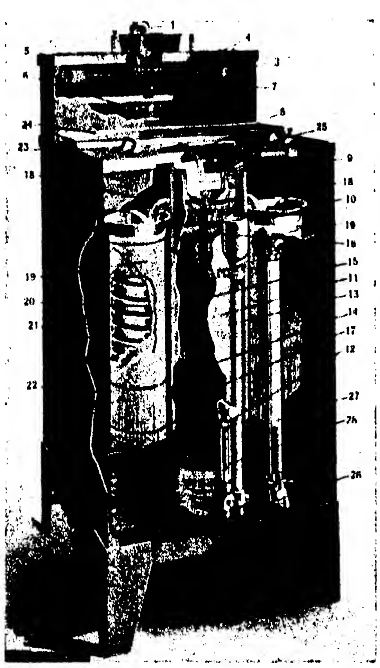


Fig. 5

Filtering Medium

The filtering medium is a special grade of cloth which does not act as a screen, but actually filters the oil, largely by capillary action. This firm has experimented with many different kinds of filtering material, and has come to the conclusion that cloth is the best. While attempts have been made to use bone-black, waste saw-dust and other loose material for filtering oil, if this material is packed loose enough to pass a sufficient quantity of oil, channels will form in the material, and a large percentage of the oil will flow through these channels without the suspended matter being removed. On the other hand, if material of this kind is packed tight enough to prevent channeling, the process of filtration is so slow that it is not practical for a commercial filter. Furthermore, loose material is always liable to work through the filter into the bearings and cause trouble.

The use of other material, such as asbestos and paper, requires considerable pressure, usually about 100 pounds per square inch, in order to force the oil through it. To maintain this pressure, small steam pumps are usually employed, and their steam consumption is so great that it does not pay to use this type of filter.

The use of a filtering medium alone is not sufficient, because the capacity of a filter purifying oil from steam engines or turbines is not limited by the filtering material, but in reality by its capacity for separating entrained water from the oil, and there is only one practical way to effectively remove water, and that is to take advantage of the difference in specific gravity between oil and water, by bringing the oil to rest in large tanks or spreading it out in thin sheets, flowing at a low velocity, so that the water will settle out by gravity.

Briefly, the operation of the Richardson-Phœnix type "S" multiple oil filter is as follows :—

(1) The incoming oil passes through one or more screens, which remove coarse particles of foreign matter.

(2) When necessary, the oil is heated to reduce its viscosity, so that water and heavy foreign particles will be readily precipitated.

(3) The oil passes at a low velocity over baffles, where water and solid matter settle out by gravity.

(4) The partly purified oil finally passes through filtering cylinders for final purification, and flows into the clean oil compartment ready for use.

(5) When necessary, the oil can be passed over cooling coils before re-using.

The oil is not passed through water in any part of the filtering process. The idea that oil can be washed by allowing it to trickle up through water is erroneous, as some oils will actually pick up more water than they give up. Therefore, type "S" oil filters operate on the dry system of filtration. The only water in the filter is a very small amount in the bottom of the precipitation compartment, which is used to seal the automatic water overflow.

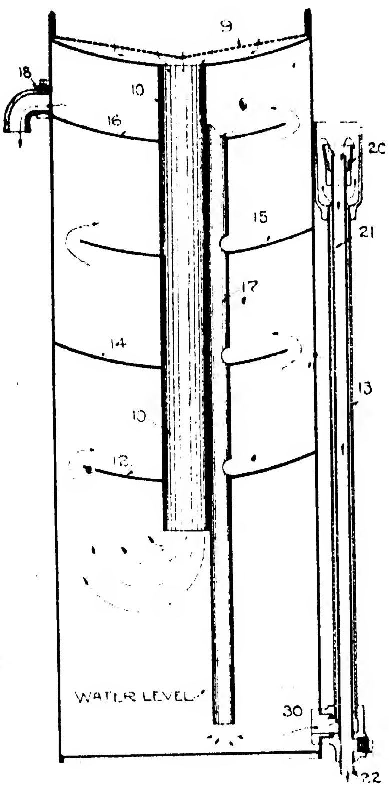
Type "S" filters are of the continuous operation type, in which a steady stream of dirty oil at a fairly constant rate, flows by gravity or is pumped into the filter. The filtered oil is drawn from the filter by a pump which delivers it to the machines to be lubricated or to an overhead reservoir. Type "S" filters are suitable for central systems and individual circulating and filtering systems for power plant machinery.

The following detailed description will make clear the operation of the type "S" filter.

"S" type Filter

Referring to Fig. 5, the dirty oil enters the filter through pipe (1), passing down through removable strainer (2), where large particles of foreign matter are strained out. The oil then falls into heating tray (3), being spread out into a thin sheet over heating coil (4), which, when necessary, can be used to raise the temperature of the oil and reduce its viscosity. Some of the larger particles of sediment and foreign matter precipitate to the bottom of the tray (3), which can easily be removed by lifting off cover (5), to which the tray is attached. The oil flowing from the edges of the tray (3) falls into the receiving chamber (6), passing out through overflow pipe (7) and out through spout (8). The overflow pipe (7) has a number of small holes which automatically maintain a uniform flow into the filter at the rate necessary for efficient filtration.

New oil may be added to the filter by pouring it into the receiving chamber (6) without any danger of flooding, as the top of the overflow



INDUSTRIAL INDIA

Fig. 6

pipe (7) is open, forming a safety vent.

The operation of the precipitation compartment will be made clear by referring to Fig. 6. The reference numbers also correspond to those in Fig. 5.

The oil flowing from spout (8) passes through removable strainer (9), which is of a finer mesh than (2). The oil now passes down through the centre tube (10) to the bottom of the precipitation compartment, and spreads out under the bottom of baffle (12), taking a zig-zag path upward, over and under the saucer-shaped baffles (12), (14), (15) and (16), overflowing through nozzles (18) into the filtering cylinders. The water which precipitates out of the oil and settles in the hollow of the baffle trays is by-passed directly to the bottom of the precipitation compartment by means of a conductor pipe (17), which has an opening connecting with the lowest point of each baffle. The particles of water are given a short path directly to the bottom of compartment (11), and do not have to struggle downward through a current of upward-flowing oil.

The horizontal baffles break the oil into layers, so that the drops of water do not have to travel through a large body of oil. In no place is the oil forced to pass through water, where it might pick up moisture and carry it into the clean oil compartment.

The water, separated from the oil, collects in the bottom of the precipitation compartment, and is automatically ejected through water overflow (13).

Referring to Fig. 6, the automatic water overflow consists of two concentric pipes. Water flows upward through the outer pipe (21), and flows away to the sewer or a sump through connection (22), or through the side outlet immediately above (22).

This water overflow simply operates on the U-tube principle; that is, the column of water in the outer pipe balances a combined column of oil and water in the precipitation compartment of the filter. As more water is precipitated out of the oil, the water in the bottom of the compartment tends to rise, and the leg of our U-tube, inside of the filter, becomes heavier, because it is made up of a greater proportion of water and less of oil, thus water flows over the top of funnel (20) until the legs of the U tube again balance, thus maintaining the proper level in the precipitation compartment. The funnel (20) can be screwed up or down on the tube (21), so that the water overflow can be adjusted for handling oils of different specific gravities.

The partially purified oil flowing from the nozzle (18) (Fig. 5) passes directly into filtering cylinders (19), which contain a body of quiet oil, giving another opportunity for any remaining foreign matter to settle to the bottom, where it can be easily removed when cleaning. These cylinders are wrapped with a double thickness of special grade of filtering cloth, the oil flowing outward into the clean oil storage compartment. The filtering cylinders have a series of holes in them, and the filtering cloth is fastened in several places, forming pockets which evenly distribute the process of filtration over the entire surface. The clean oil occupies all of the space in the filter shell surrounding the filtering units (19) and the precipitation chamber (11).

The filter can be easily cleaned without interfering with its continuous operation by removing cover (23), and turning one of the nozzles (18) so that it points up, which prevents the oil from flowing into the filtering cylinder to be cleaned. The filtering unit can then be taken out and set in the drip pan (24), which is connected to spout (8), allowing the excess oil to drain directly back into the filter. Pockets (25) on the under side of the cover contain extra filter cloths. Cloths can be used over and over again if they are washed in gasoline or kerosene. A flush connection in the bottom of the precipitation chamber (11) permits of washing out the sediment when necessary. The trays in the precipitation chamber should be removed occasionally and washed off. These trays are all attached to the central tube (10), and can be removed by taking out the screen (9) and lifting out the entire stack of pans.

Gauge (28) shows the water level in the precipitation compartment. The funnel in the top of the overflow should be so adjusted that the water level shows about one inch above the bottom of gauge glass (28). Gauge glass (27) shows the level of the oil in the clean oil department. The cock at the bottom of this glass is for drawing off clean oil for use in hand oilers. When the filter is used as part of a continuous oiling system, the clean oil is drawn off through a pipe connection in the bottom of the clean oil compartment (22), as shown in Fig. 5.

Modern Grinding Wheels

(*Continued from page 256.*)

Unfortunately the truest grinding wheel is often attended with fatal results to the operator, in which case it is impossible to question him as to what happened. After being tested, the wheel, before finally being sent away, is inspected by an expert to pass same as being of correct dimensions, and that it is true to the grit and hardness required, it is then stencilled and despatched to the customer.

A Marine Internal-Combustion Engine

without Piston Rods

Many attempts have been made in recent years to evolve a double-acting internal-combustion engine, with its obvious advantages, which would avoid the practical disadvantages of such design. The engine described in this article would appear to have made a very considerable jump along the line of such progress, and to hold considerable possibilities for solving the problem of the high-power engine.

WE recently had the privilege of inspecting a novel design of internal-combustion engine under construction, which has been evolved primarily for ship propulsion, but, as will be seen from the following description, the principles involved are equally applicable to the land type design.

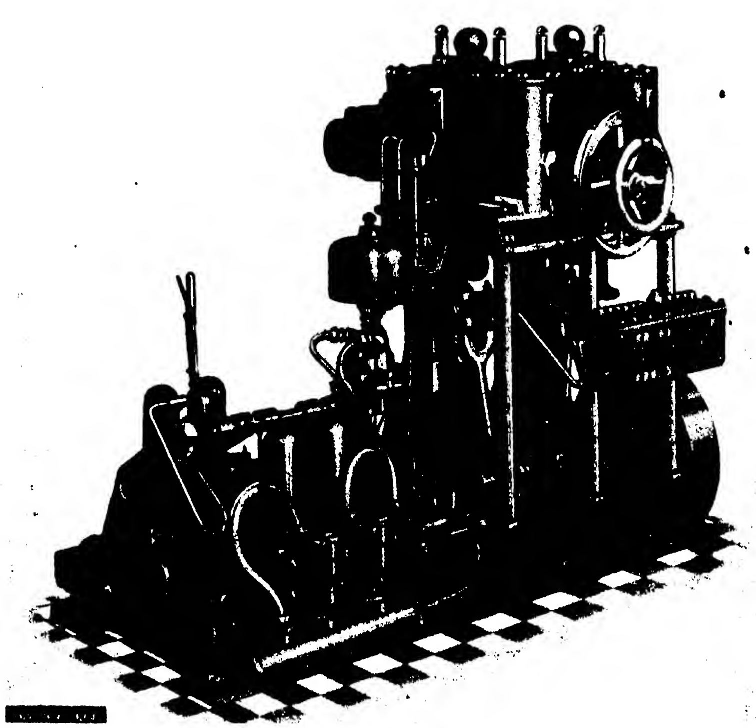
Before going into detail, we would say that one of the principal novelties in the design under consideration is the fact that the ordinary piston rod is entirely dispensed with, the design embodying a double-acting piston, and, as will be seen on reference to the section, the motion is carried from the piston to the crosshead by means of two side rods attached to a gudgeon pin passing through the piston.

The makers of this engine have evolved several different arrangements for attaching these side rods to the piston, the one illustrated being used in the smaller sizes. In the larger engines the scavenging pumps are mounted quite separately from the cylinder, with the result that the piston side rods are not required to make a gas-tight joint between the pumps and the cylinder. The gudgeon pin in this case works in an open slot, and, of course, never making any communication between the cylinder itself and the atmosphere.

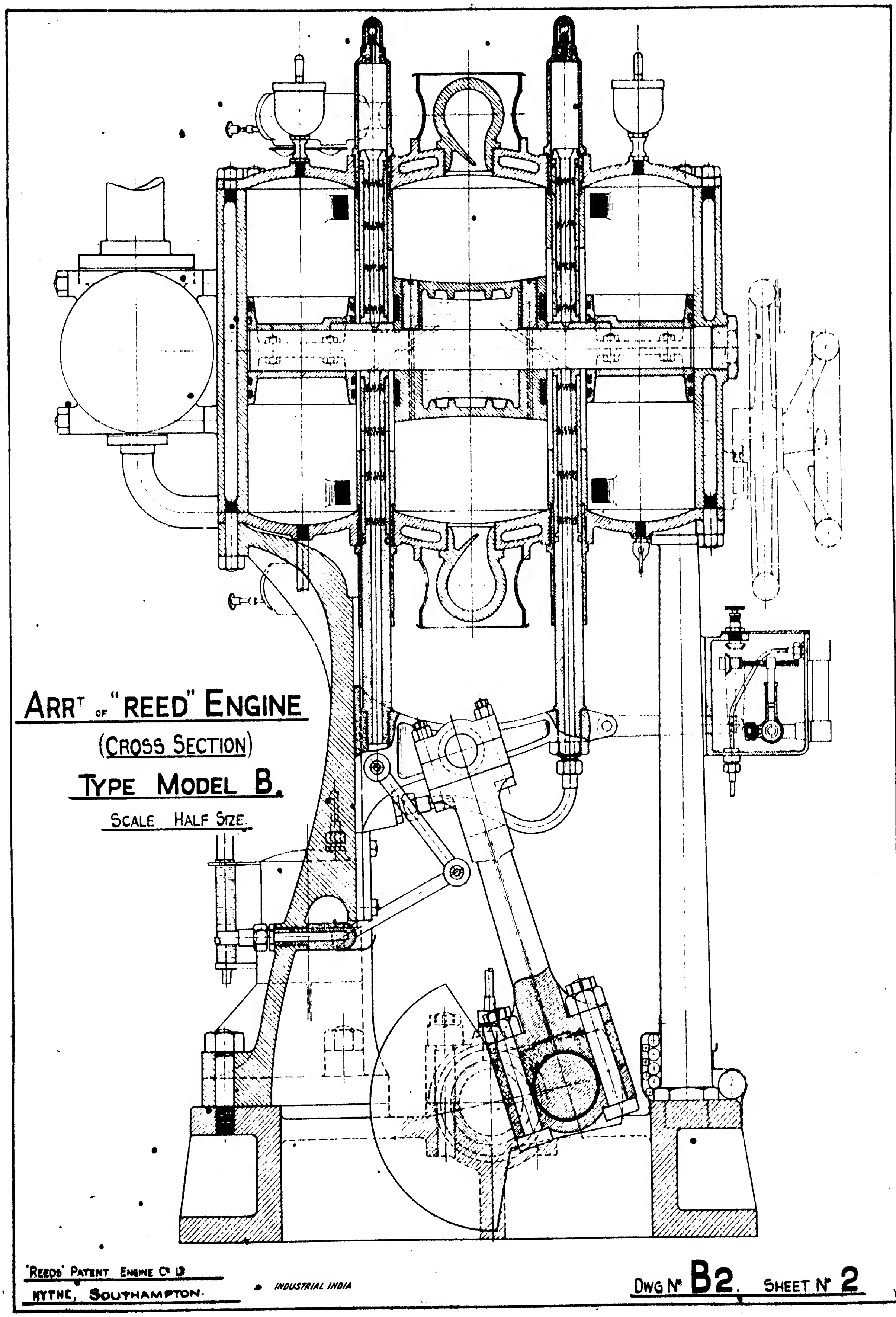
The importance of this somewhat radical departure in design is not only confined to the elimination of a stuffing-box, although all those who have had experience of a stuffing-box on an internal-combustion engine, know what a vitally weak point in an engine this is, but on reference to the section it will be seen that almost ideal conditions prevail for the working conditions of an internal-combustion engine, that is to say, the shape of the combustion space is symmetrical, and the cylinder proper is of the simplest design, and there are no parts of intricate design (either fixed or working) which are subject to the intense heat of combustion, and it will be noted, of course, that the piston itself is water cooled.

We need not point out the great advantage of a double acting engine for marine purposes having an impulse at every stroke, this result following because the engine works on the two-stroke principle; but what is of even greater importance when combined with the even turning, is the fact that the makers claim a mean effective pressure in the cylinder of some sixty pounds per square inch. This figure seems to indicate very perfect working as an internal-combustion engine, and would also appear to confirm the makers' statement that for equal cylinder capacity and speed, the engine will develop approximately equal horse-power with the average marine steam engine, and this fact, combined with the positive reversing and control gear which we will describe presently, appears to us to somewhat revolutionise the prevailing conditions as regards internal-combustion engines for marine work.

The following figures regarding fuel consumption, which have been supplied to us by the makers, are interesting in view of the above claims. The makers claim a consumption of .48 lb. per B.H.P. per hour on engines above 100 H.P., and a consumption of .5 lb. per B.H.P. per hour on engines under



View from bilge pump side.



ARRT OF "REED" ENGINE
(CROSS SECTION)
TYPE MODEL B.
SCALE HALF SIZE.
'REEDS' PATENT ENGINE Co Ld
HYTHE, SOUTHAMPTON.
INDUSTRIAL INDIA
DWG No B2. SHEET No 2

100 H.P. It should be pointed out that these are consumptions by weight on engines of the semi-Diesel type, and must not be compared with consumptions on the pure Diesel type.

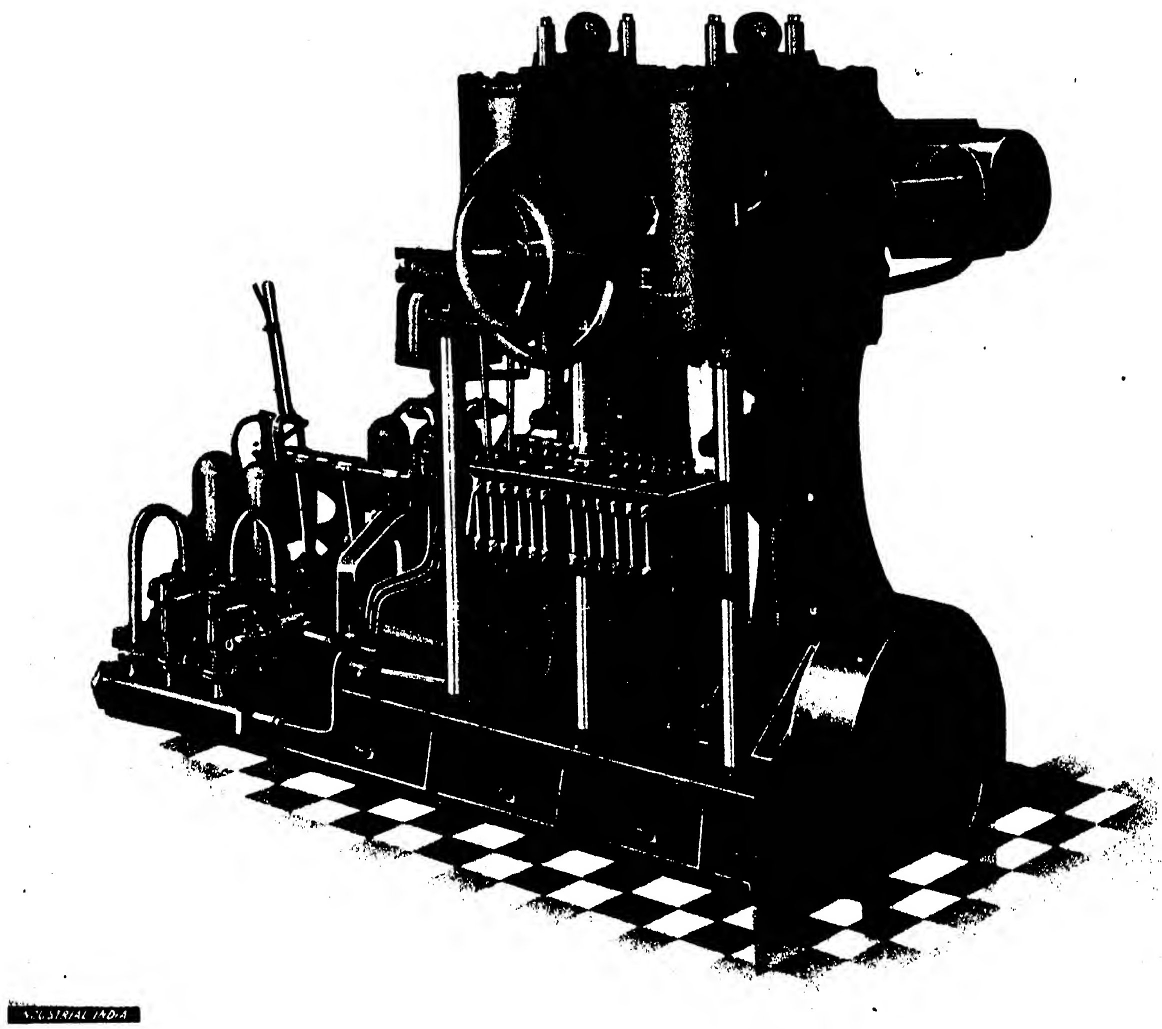
Regarding size and weight of this new design—an engine of 30 H.P. occupies a floor space of 11½ square feet, and is 3 ft. 4 in. high from the centre line of the crankshaft. The weight of this engine is 22 cwt. These figures will give some indication are included in the above dimensions.

Turning now to the patent reversing gear of this firm, as will be seen from the photograph, this consists of a set of ports cut in circular plates, these circular plates rotating against one another by means of the handwheels shown.

It will be seen in the illustrations that there are two operating wheels; one is connected to the governor, and controls the travel of the fuel pump,

The second wheel operates the oil ports in such a manner that the fuel oil supplied from the fuel pump may be directed to the top or bottom of any cylinder, and it follows, from this arrangement, that oil can be injected and fired exactly as required, either to send an individual piston up or down, and the arrangement is such, that the engine is driven either ahead or astern in a positive manner.

Compressed air, which is automati-



View from flywheel side

of the advancement made by this design, which, if compared with the larger size engines, is a matter of some considerable importance. It should be pointed out that in this particular size, the pumping gear (including the water circulating pump, the air compressor and the bilge pump) are arranged on the engine bedplate and and therefore, of course, the amount of oil delivered to one cylinder end per stroke. This wheel, therefore, controls the speed of the engine, either for full, half, or quarter speed, the governor automatically taking control over any speed below that fixed at the point under control by the operating wheel,

cally distributed to each cylinder in proper rotation, is used for putting the engine in motion, and after speed is attained the engine carries on under its own power, and we should point out here that where the hot bulb of the engine has not previously been heated, that starting from cold can be effected by means of a patent

electric iguitor, which we are not yet at liberty to describe.

Unfortunately we have not space available to follow in detail the working of the reversing gear, or, more correctly, the reversing and control gear, but we think from the above description, together with photographs, that what is actually effected in practice will be clear to our readers, namely, that a mere novice can control the engine by merely turning the pointer on the control wheel to what he requires the engine to do, either to go ahead or astern, or to operate at quarter, half, or full speed. The result follows exactly as it follows similar control on a steam engine, and it follows because the control wheel directs the oil by means of ports to that side of the piston where power is required to rotate the crankshaft in the desired direction, and the governor gear is operated to increase or decrease the travel of the fuel pumps as may be required for speed control.

The actual operation of this gear is positive and fool-proof, and when seen in reality, the construction and method of working is really extremely simple, and it seems to us that it is an enormous advance in the design of control gear for a marine internal-combustion engine, not exactly because it eliminates the mechanical reversing gear, or other form of secondary gear, but that it is positive in its action, and is extremely simple in control.

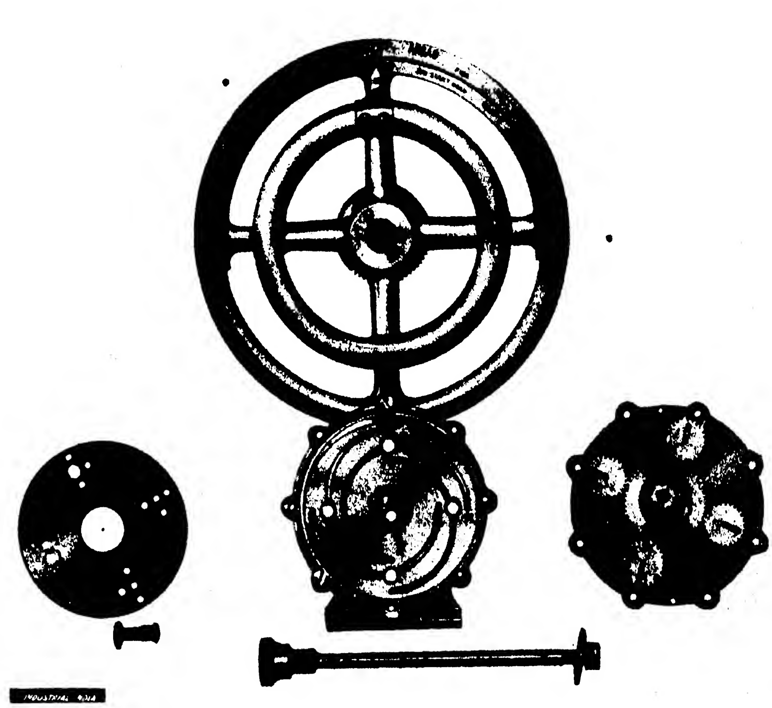
We have already pointed out that this engine works on the two-stroke principle, and it follows that every stroke of the piston is a power stroke; in other words, a single-crank engine of the Reed type is equivalent to a four-crank engine of the four-stroke single-acting type, or two-crank engine of the two-stroke single-acting type. The advance in design on this point is not wholly confined to the smaller floor space occupied, or to the fact that a lighter engine is evolved, but it also means that the adoption of the Reed design enables a more even turning movement to be effected, and, therefore, more nearly approaches the turbine effect than any other type of reciprocating internal-combustion engine.

The following information which has been supplied by the makers regarding their present arrangement for manufacture is of special interest as regards marine work. Their type "A" engine, which is fired by magneto, and is designed to start on petrol and run on paraffin, has a cylinder of 2¾ in. diameter by 3 in. stroke, and is made in one, two, four and six cylinders, having 6, 12, 24 and 36 H.P. respectively at 800 r.p.m.

The design of the crankshaft on this engine is somewhat novel. For example, in the six-cylinder model there are six cranks set at thirty degrees, and therefore all on one side of a half circle. In this way the six-cylinder engine obtains thirteen power impulses per revolution, which is very nearly approaching the turbine effect.

What is known as their "B" type is a hot bulb crude oil engine, which can be supplied with the firm's patent electric apparatus for cold starting. This type is made in four models, having 1, 2, 3 and 4 cylinders of 25, 50, 80 and 110 H.P. respectively. This model has a 6 in. bore and 8 in. stroke, and develops its power at 300 revolutions per minute.

Forced lubrication is supplied to all main working parts of this engine, but is supplied under somewhat novel arrangements. The usual force pump is discarded in favour of compressed air, which is applied on the top surface of the oil in an air-tight tank. This supply tank is fed from a second overhead tank, and the arrangement is such that the supply is kept up automatically. This is a novel and very interesting feature, because it not only ensures positive lubrication, but the secondary supply tank acts as a guide for the engine attendant, that he may know what his oil consumption is over a given period, and he also knows that his lubricating system is working properly.



Reversing Gear dismantled

Another novel point in the general arrangement of this engine is the fact that the circulating pump which supplies the jacket and piston water is the same size and design as the bilge pump, and these two pumps are arranged in such a manner that they are not only interchangeable, but that the change over is automatic, by means of an ingenious arrangement operated by compressed air, and this automatic action comes into operation should for any reason the circulating water system fail to act.

The above is a very brief description of what this new design really means, but it will be evident by comparing the above features with present standard practice that there are a number of other minor points which may be claimed for the Reed design, and we understand that the makers anticipate building this engine for very high powers, not only for marine work, but also for stationary work, and we hope in a future issue to give further details of these very interesting developments, which the makers and patentees, Messrs. Reed's Patent Engine Co. Ltd., of Hythe, Southampton, are proceeding with.

An Important Engineering Enterprise

A brief outline of the growth of a well-known British metal manufacturer.

A BRANCH of the engineering industry long prominent in England, and never more noteworthy than at the present time, is that represented by Messrs. Elliott's Metal Co. Ltd., Selly Oak Works, Birmingham, who occupy a foremost position among the metal manufacturers in and around that important industrial centre.

The company has been established for close on fifty years, and, as in the case with many other firms, in the earlier years operated in a small way of business, gradually increasing in size and importance, until at the present time it has become one of the most considerable concerns of its kind, giving employment in normal times to close on 1,000 workmen.

The works to-day cover a considerable area, and are equipped with the latest machinery and appliances for all processes of the industry carried on.

Elliott's Metal Company is widely known as manufacturers of copper and brass plates, rods, sheets, wire and tubes for every purpose, also of condenser plates and tubes of all alloys, and yellow metal in every form. The company also specialises in copper plates for locomotive boilers, for many years supplying the principal home, colonial, and foreign railways. The manufacture of H.C. wire also largely occupies the company's attention, their works being specially equipped for the work, and British and colonial telegraphs and telephones being largely supplied by them.

With regard to the above indicated classes of goods, we may say that a standard is maintained throughout, which is the highest possible in efficiency, in order that the general confidence with which the Company's products are regarded by the various industries making use of them may be fully justified and retained.

To the widespread general distribution of Elliott's Metal Company's products, and the good name they bear abroad as well as at home, there is testimony in the substantial connections which have been developed during many years past all over the country, and in the chief centres of our export trade.

They have found their markets in all the principal countries of the world that are open to British enterprise, and the reputation of their output is of the highest, placing their products in the forefront of the market as regards steady demand and the assured confidence of buyers and users.

In India their products are well known and extensively used. For close on fifty years, Elliott's Metal Company has exported regularly to Bombay, Calcutta, Madras, and Karachi markets large quantities of squares, sheathing, and circles, in yellow metal and copper, under their deservedly popular brand.

Another feature of the Company's trade with India is the demand for its brass and copper wire (sent out in all gauges), and soft copper rods.

The actual work through all processes is keenly watched, and comes under the personal supervision of the management, and the constant supervision and attention to details thus eliminates any fear of unsatisfactory work, with the consequence that their various products never fail to give complete satisfaction, complaints being practically unknown.

The works have been organised with the following points held constantly in view; strict adherence to these points has been a big factor in promoting the success of the enterprise. The first is that while always working for a maximum output, quality is never sacrificed to quantity; thorough workmanship and finish can always be relied on. Secondly, every attempt is made to adhere to delivery promises, and it is noteworthy that their promises are rarely broken, and then only when due to circumstances entirely beyond control. Thirdly, the same care and attention is bestowed upon the small order as upon the large one, and no large order is allowed to take precedence over a small one which may be due for earlier attention in order of rotation. A fourth point is that a "Store" system is employed, whereby the minimum delay on account of sudden shortage of material is assured.

The entire business is a fine example of modern organisation and efficiency, developed upon an old-established foundation, and supported at every point by long accumulated experience and high technical qualifications.

It has always been the company's policy to manufacture only the very best, to represent fairly, to deliver good value, and, finally, to preserve goodwill.

LOW TEMPERATURE CARBONISATION

(*Continued from page* 249.)

Finally, it is interesting to note that Mr. Maclaurin uses, to determine the probable oil yield from any given quantity of coal, an ingenious laboratory apparatus consisting of a vertical tube closed at its upper end, containing about 100 grams of the powdered fuel. The lower end of the tube is open, and dips under water, and the tube is then heated carefully with a burner, commencing at the top. The oil runs down into the water, and can be collected and measured. The results of typical coals tested in this way are shown in Table II.

An engineering visitor from the United States to Great Britain recently paid his testimonial to the excellence of the modern plant installed at British ports for the handling of coal and of ships' cargoes in general. The high standard of efficiency thus indicated is being shown in connection with the discharging and storing of grain. The Clyde, for example, now possesses one of the finest granaries, and there was recently installed a pneumatic suction grain elevator which has a capacity of one hundred tons of grain per hour.

TRANSPORT

Conducted by "M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH :: :: THE MANAGEMENT AND CONTROL OF RAILWAYS :: :: ::

Indian Railway Developments

A review of the Improved Facilities now being introduced on the Indian Railways, and an outline of probable future tendencies.

THE Acworth Committee, which investigated the working of the Indian Railways, and submitted a most comprehensive report, laid great stress upon the fact that, owing to the dearth of traffic facilities, much of the country's produce was lost, and that which eventually did get to market was frequently conveyed by uneconomical means at an unreasonably high cost. The shortage of rolling stock was largely blamed for this state of affairs, but the inadequacy of track and terminal facilities was also held largely responsible. It is of little use having a supply of rolling stock sufficient to meet the requirements of the traffic under normal conditions unless it is enabled, by means of adequate facilities, to obtain the necessary mobility. In any other event, an excessive quantity of rolling stock inevitably leads to congestion, which is aggravated in direct proportion to the number of vehicles standing immobile.

Thus arises the need for a sense of proportion, and it is worthy of record in these pages that, speaking generally, the whole of the Indian Railways are now engaged in a strenuous endeavour to make good the defects that have manifested themselves. Not only are they obtaining new rolling stock to make their stocks equal to, at least, the normal expected demand—and that is as much as can be expected of any railway undertaking,—but they are engaged in wholesale remodelling of stations and yards, line widenings, the placing in of additional crossing places on single-track lines, the improvement of the signalling, the tightening up of the organisation, and, in fact, in any other work that is likely to improve the handling of traffic.

It will be recalled that at the end of Chapter II (Present Situation of the Indian Railways), there is the definite indictment that "while congestion at some time or at some place is a commonplace of railway management in every part of the world, in India it has for years past recurred each season. It has now become normal, and will become permanent unless bold measures are taken to deal with the situation." This was by no means pleasant reading for the Indian railway authorities, who, while recognising the truth of the statement, argued—and with some justice—that the war had a lot to answer for. Locomotives, wagons and track were sent to various theatres of war, and the great steelworks of Tata & Company Ltd. were drawn upon almost exclusively to supply rails, etc., for war purposes. This naturally did not help the Indian Railway Administration, but they have now grasped the nettle firmly, and by their recent allocation of a large sum for railway purposes, have gone a long way—although not far enough—towards meeting the railway needs of the present and the immediate future.

New Lines under Construction

In view of these facts, it will be interesting briefly to recapitulate a few of the improvements that are now projected or in progress, and it may be worth while first to note the references in this connection that are made in the Indian Railway Report for the year 1920-21, and supplement those remarks with information that has recently been made available.

Take, first, the development of new lines. The Hukong Valley route of the Indo-Burma Connection Railway, which was surveyed last year, is of extreme importance, in that it will provide a connection between the railways in India and Burma—a matter of considerable interest. Then the project for tube railways in Calcutta is one of great local importance. The traffic needs are extensive, and are growing rapidly, and there can be little doubt that a system of tubes, established on the most modern methods, would do much to relieve the congestion from which Calcutta is suffering, and from which she will suffer in greater volume if some additional traffic facilities are not introduced ere long. The Agra-Karachi Connection Railway, which has also been surveyed, is a facility that has long been desired by the trading public of the United Provinces and Karachi, while the lines such as the Monharpur Railway and the Mirzapur-Maihar and Daltonganj-Hutar Railway are designed to serve new area where coalfields are now being developed.

While this is all very well, the average reader, knowing something of Indian conditions, will aver that equally important is the improvement of existing facilities. I quite agree with this view, but attention should not be concentrated on existing facilities exclusively. Development lines are very necessary, and in such a vast country as India, where there are large areas still awaiting exploitation, it would be in the highest degree prejudicial to national interests if development schemes, especially those promising a sound return, were stopped. But we may now turn to the question of existing facilities.

Yard, Line, and Station Improvements

In the 1920-21 Report, reference was made to the remodelling of 41 station yards, the most important of which were at Nagpur, Sealdah and Belliaghata, Bezwada, Tondiarpet and Poona, and it will give an indication of the extensive work involved when it is stated that the estimated cost of the improvements to these five yards is Rs. 2,37,89,649. It is also pointed out in the Report that the administration of nearly every railway insists

upon the necessity for the provision of extended repair facilities, larger yards, station improvements, more crossing stations, better water supply and quarters for staff, while the Bengal-Nagpur Railway, for its part, is making progress with a big scheme for the general improvement of traffic facilities which is estimated to cost about 2½ crores of rupees.

Let us then see what is being done by individual companies, these serving to show the general trend of development. The East Indian Railway is reported from Calcutta to be engaged on an extensive scheme of general improvements. For example, the main line from Calcutta is being quadrupled between Burdwan and Khana Junction, and the extension of a third line to Ondal is under consideration. From Ondal to Barakar, the main line is being given an additional road, while in certain places quadruple tracks are being arranged. Naturally, this kind of work brings in its train the necessity for enlarged capacity at terminal points, and it is stated that large additions to various yards are in progress.

The provision of adequate facilities in connection with coal traffic is recognised to be of vital importance, and in the Jherriah coalfield, the line from Dhanbad to Phularitand is in course of being doubled, while extra yard accommodation is being provided at Dhanbad and at all the stations intermediate between Dhanbad and Katrasgarh. These alterations and improvements, with others now in contemplation, will permit of the effective handling of a greatly augmented traffic in the down direction, and thus assist the flow and accelerate the movement of empty wagons from the northern and western directions. Of course, free traffic movement is not merely a question of station facilities—a point I insist upon because of its extreme importance. Line and terminal accommodation must bear a suitable relationship to one another, and to improve line facilities a large number of new passing stations are being laid in, and in some localities the line is being doubled.

Bengal-Nagpur Schemes

The Bengal-Nagpur Railway, as indeed most of the other administrations, has a similar development scheme in hand. In this scheme figure new lines, extensive improvements at stations and enlargements of workshops, together with the purchase of locomotives and rolling stock requisite to bring the rolling plant up to the required standard. With regard to the Vizagapatam harbour scheme, it is understood that the organisation of a distinct company has been decided upon, and that the new company will deal not only with the harbour scheme, but also be responsible for the construction of the railway from Raipur, in the Central Provinces, to Vizagapatam. *The Englishman* also reports that the Bengal-Nagpur Railway has launched out on a venture which is likely to have far-reaching effects on the building trade in India. The railway company is stated to be investing 12½ lakhs of rupees in a modern brick factory, which is to be erected at Gokalpur, near Khargpur. Power for the factory will be taken from the Khargpur power house, and it is anticipated that, by means of the patent devices installed in the factory, bricks known in the building trade as "first class" bricks can be manufactured at three to four rupees per thousand cheaper than the prevailing market rates.

The Eastern Bengal and Great Indian Peninsula Railways are also pressing on with development schemes. In the former case the standard gauge line is being extended as far as Siliguri, and conversion of the metre gauge between Santahar and Siliguri being well in hand. This district, which is a most fertile area, should yield a rich return for the company's enterprise, and avoid the waste of money and loss of time unavoidable when transhipment has to be effected. On the Great Indian Peninsula, reference may be made to the proposals for the reorganisation of the operating departments, in order to develop the traffic supervisory arrangements on a broader and more complete basis. There is also the extension of the train control system, which has abundantly proved its worth, while, as on other lines, the remodelling of various yards is in progress.

Considerable improvements have recently been made at Bhusawal marshalling yard, where the introduction of semi-gravity shunting expedites the shunting operations and effects economy in working. This busy yard deals with over 1,000 wagons per day during the traffic season, and until the recent alterations, serious congestion arose at busy periods owing to the inadequacy of the facilities. Since the shunting neck and sorting sidings have been regraded, however, the sorting of wagons has been expedited; in fact, it is estimated that fully fifteen minutes has been saved in the sorting out of a train comprising forty-five wagons, taken on the basis of the average number of cuts.

The Result of the Improvements

While it is yet too early to appraise the result of the improvements which are now being made in various ways all over the railways of India, it is at least pertinent to suggest that the decision to spend Rs. 150 Crores during the next five years will undoubtedly lead to very considerable improvements in the railway communications. So far as information is available at the time of writing, nothing else of an important character has been done in connection with the recommendations of the Acworth Committee, but it is understood that careful investigation is being made of various aspects, and that, very shortly, an important meeting will be held to determine on further steps on the lines indicated in the Report.

One important innovation should here be noted. I refer to the appointment by the Viceroy of Mr. C. D. M. Hindley, Chairman of the Commissioners of the Port of Calcutta, to be Chief Commissioner of Railways. Mr. Hindley, who was for a long time Agent of the East Indian Railway, has been appointed consequent on a recommendation in the Acworth Report, and, when he settles down, he should be able, by virtue of his wide powers, to do much to enhance traffic working efficiency.

If traffic is to be developed—and in India there is tremendous scope for development—there must be adequate transport facilities, and now, at long last, there appears to be a possibility for the facilities to go ahead, if ever so slightly, of the requirements, and not lag behind as in the past. That is the obvious direction in which development should be hastened, for the growth of India's industry, the continued advancement of her agriculture—and, in fact, the whole of India's material progress, must go hand in hand with railway expansion. Other forms of transport, such as road and air, will tend to become more comprehensive and more useful, but it is indisputable that for the real transport work of a nation, railways constitute the main arteries—and will long continue to do so.

Recent "Garratt" Patent Locomotives

Some recent developments in the well-known "Garratt" design of Locomotives, by courtesy of the "Railway Engineer."

IN 1909, the first "Garratt" patent locomotive was designed and built by Beyer, Peacock & Co. Ltd., for the 2 ft. gauge line of the Tasmanian Government Railways, known as the North East Dundas Section. This engine was naturally of relatively small size, although of great tractive effort for the gauge. It was of the plain 0-4-4-0 type with compound cylinders, high pressure 11 in. by 16 in., low pressure 17 in. by 16 in., wheel 2 ft. 7½ in. diameter, and of a total weight, full, of 33½ tons, with a tractive effort of 14,334 lb. at 75 per cent. boiler pressure. Since that time the "Garratt" locomotive has been greatly developed by the holders of the patent, Beyer, Peacock & Co. Limited, until the latest example weighs 133¾ tons in working order, and has a tractive effort of 47,385 lb. at 75 per cent. boiler pressure.

It might, perhaps, be well to say that the "Garratt" locomotive is of the articulated type with two separate engine units or bogies connected by a frame carrying the boiler. Unlike any other form of articulated engine, however, these units are placed one at each end of the boiler frame, which is thus left free to accommodate the boiler, the size of which is only restricted by the loading gauge, as the water and coal are carried on the engine frames. This latter construction is also an essential feature of the "Garratt" patent, and the weight of the tanks, etc., being directly on the engine units, conduces to their steady running.

An indisputable advantage arises from the method of carrying the boiler in a long girder frame unencumbered with tanks, etc., and away from the wheels, for the reason that, apart from the practically unlimited size of the boiler, its construction is on the simplest possible lines with large water spaces; the copper stays, etc., are readily reached for inspection and repairs, while the washing out doors, etc., are unusually accessible.

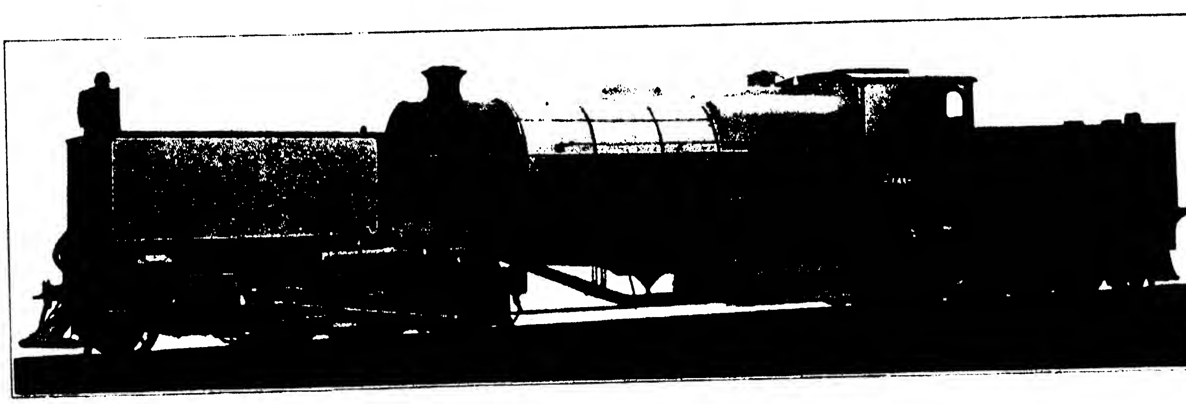
As there are no axles under the firebox, this can be made of any reasonable desired depth and volume, and this feature combined with the moderate length of the tubes, has much to do with the excellent steaming qualities and economy in fuel obtained in actual service.

The ashpan also is very accessible, as not only are the ends fitted with the usual air admission doors, but each side has a large cleaning door or doors.

The location of the pivot connection on the engine frame is determined by accurate calculations of the various weights of the parts of the vehicle, and their effect upon the wheels. It is obvious that the weight of the boiler and the girder frame must be carried on the engine units or bogies at such a point as will balance the weights of the cylinder, frame, tanks, etc., which lie towards the outer end, and to provide the necessary weight on the innermost wheels.

The weight distribution is naturally affected by the gradual consumption of the fuel and water, but as they constitute only a small proportion of the total weight of the locomotive, the variation of the adhesion weight on the wheels is not a serious problem, and is certainly not more so than in the case of a normal type tank engine, in fact, when the engine is empty—a condition in which, of course, it could not work there is always sufficient adhesion weight for the tractive effort, so that the weights of the fuel and water are, in fact, only so much extra adhesion weight; this is a point to be clearly recognised.

It is a mistaken, but rather common idea, that the primary object of the "Garratt" engine is to provide an articulated engine for the easy negotiation of curved lines, but while this is a valuable function it is not the main object of the design, this being the provision of engines of a



Express Passenger Locomotive "Garratt" System, San Paulo Railway, Brazil

DETAILS OF "GARRATT" LOCOMOTIVES

Railway.	Gauge	Type of Engine	Cylinders* (diam. and stroke).	Coupled Wheels (diam.)	Total Wheel-base.	Total Heating Surface.	Grate Area.	Boiler Pressure.	Tractive Force at 75 per cent. B.P.	Weight in Working Order.	Water Capacity.	Coal Capacity.
	ft. in.			ft. in.	ft in.	sq. ft.	sq. ft.	lb.	lb.	tons.	galls.	tons.
S. African	3 6	2-6-6-2	18" × 26"	4 0	58 7	*3,081	51.8	180	†47,385	133.75	4,600	9
,,	3 6	2-6-2-2-6-2	12" × 20"	3 6½	53 0	*1,222.6	23.3	180	18,290	70.5	2,000	4
,,	2 0	2-6-6-2	10½" × 16"	2 6	39 0	976.8	19.4	180	15,870	44.75	1,350	2½
Mogyana (Brazil)	3 3⅜ (metre)	4-6-6-4	14" × 20"	3 9	56 0	*1,536	27.3	160	20,900	75¾	2,000	4
San Paulo (Brazil)	5 3	2-4-4-2	16" × 24"	5 0	47 10	*1,845	30.0	160	24,580	80.5	1,500	2½

* This includes superheater surface. † This engine at 80 per cent. of the boiler pressure develops a tractive force of 50,554 lb.

range of power unattainable with the conventional combinations of wheels and a super-imposed boiler. As all designers of powerful engines know only too well, the trouble is in providing a boiler to meet the required demands; the results being boilers of expensive construction, embodying very long barrels—of questionable value—wide and shallow fireboxes with combustion chambers, the latter introducing many additional joints. All this is remedied in the "Garratt" locomotive, in which the boiler is made on the plainest possible lines, while providing a grate which, of reasonable length, has ample area for the economical burning of the fuel, as its width can extend to the full diameter of the barrel, or more if required, while the depth is variable to suit the class of fuel to be burnt. The large firebox volume guarantees perfect combustion and a high evaporative efficiency is ensured by the large surfaces which collect the radiant heat of the fire.

For lines having a light permanent way, or a bridge or bridges for which the permissible weight per foot run is very restricted, the "Garratt" engine offers a solution of the high-power engine problem, as its weight per foot run is, for equal power, the lowest obtainable in any locomotive.

In construction, the "Garratt" locomotive is the most simple form of articulated engine, as, by virtue of the correct weight distribution, no spring controls, either vertical or lateral, are necessary. Apart from the ball joints on the steam pipes, there are no complicated details differing from the ordinary locomotive, in fact, the "Garratt" locomotive is in reality only two engines with one boiler.

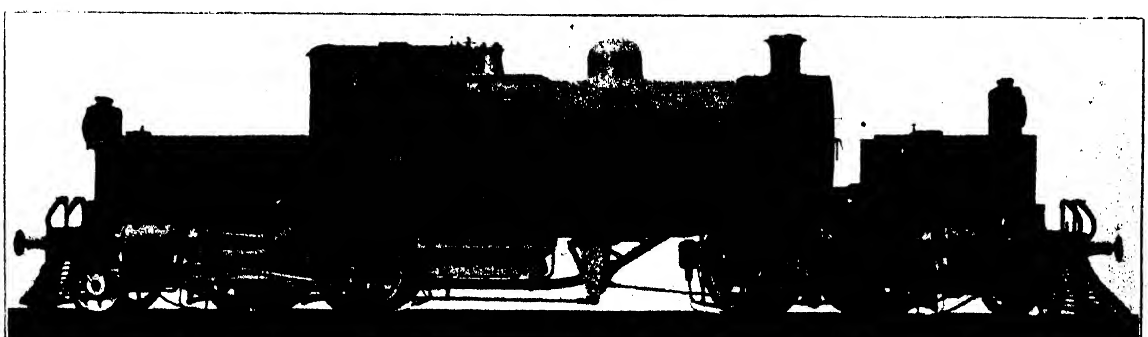
Regarding the ball joints, we understand that with the design used by the makers absolutely no troubles are experienced, and the joints run from general repair to general repair without attention, thus disposing of the old bugbear of articulated engines.

Another valuable feature of "Garratt" engines is, they are true "double-enders," being able to run with equal facility in either direction, so avoiding the necessity for long turntables, and saving the time expended in turning round, an important item when working a "shuttle" service.

Objection has been raised by some engineers to the long steam and exhaust pipes, but in actual practice these are not found to be a disadvantage, and we have seen indicator diagrams, taken from a series of "Garratt" engines in main-line traffic, in which the cards from the hind cylinders show practically no difference from the front cylinders in the height of the steam and back pressure lines.

In order to show the development of the "Garratt" locomotive, and to indicate some of the various conditions for which engines of this type have been constructed, we reproduce photographs of recent examples, for the originals of which we are indebted to the courtesy of the builders.

(To be continued.)



Latest Type "Garratt" Locomotive, South African Railways

The Container Car

We publish below extracts taken from a letter of one of our readers, which emphasises the value of the container car in transferring goods from one gauge to another

THE interesting article in your May issue on "The Container Car on American Railways" opens with the caption, "The successful utilisation of container cars on American Railways prompts consideration as to whether this class of vehicle, and its related operating methods, might not advantageously be introduced on the Indian Railways in their improvement schemes."

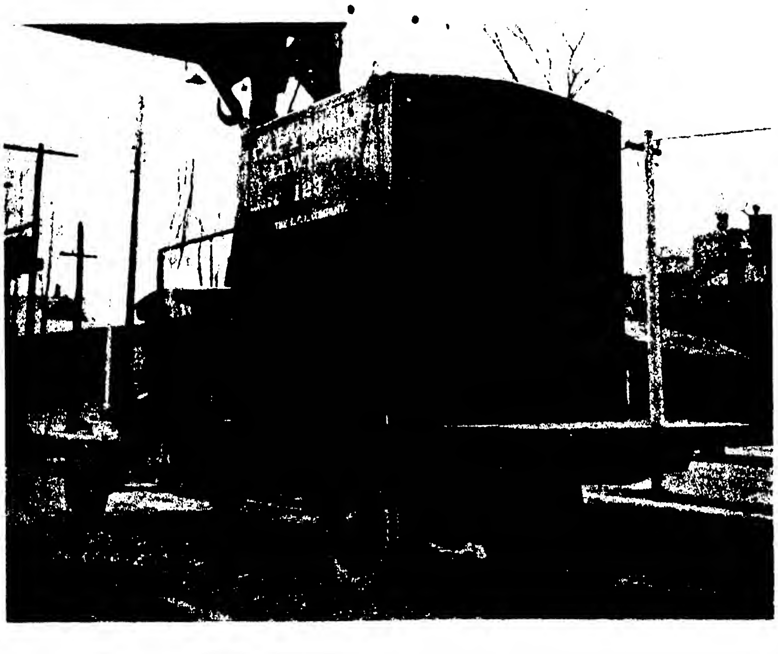
While your paper brings out most clearly the advantages seen by American railwaymen, most of which should apply with equal force in India, it seems to me that there is another advantage in the system, not applicable in America, but peculiar to India, one which would recommend it to those who face the present shortage of funds for capital expenditure.

India has a serious problem which America does not have, in the existence of two gauges, a broad gauge suitable for trunk and terminal lines, and a metre gauge suitable for extension from the broad gauge railheads into districts of light traffic. The problem is whether to further extend the broad gauge, greatly reducing the number of miles that can be built, but providing unbroken routes to the ports; or whether to extend the metre gauge, opening up far more new territory, but subjecting all through traffic therefrom to the delay, expense and risk of a piecemeal transfer from one set of wagons to another at the broad gauge junctions.

Imagine, then, a set of container cars quite similar to those described and pictured in your article, but with the containers of such horizontal dimensions that the long side of the rectangle should be proper for the width of a standard-gauge wagon, and the short side of the rectangle should be proper for the width of a metre-gauge wagon. This rectangle would be in the neighbourhood of six feet six inches by nine feet, not unlike the type successfully in use in America. Then the transfer at the junction point would consist of lifting (say) six containers off a broad-gauge wagon on which they take up a space 9 feet by 39 feet, and replacing them endwise on two metre-gauge wagons, each providing a space 6½ feet by 27 feet.

At the ideal junction point there probably would be an overhead gantry crane, spanning several broad-gauge and several metre-gauge tracks, and one or more classification platforms. The transfer would be a matter of minutes only, all risk of pilferage would be eliminated, and perishable goods would be subjected neither to delay nor to the deterioration that must come from handling piece by piece.

Such a system, then, by removing so many of the bugaboos of the transfer station, would strengthen the argument for extending the metre gauge, at least temporarily. Thereby, so much money could be saved on road-bed construction, that the adoption of the container car, instead of belonging to the class of luxuries which would be well received were it not that they call for initial expenditure from a lean purse, would become the determining factor in reducing the sum total of expenditure necessary to reach and serve a given number of points.



Container on Motor Vehicle

Among the numerous suggestions for utilising rubber, few are more attractive than the proposal to make rubber a constituent of paper. The means by which this may be successfully done have been worked out by a British inventor, who has made experiments on a considerable scale.

Locomotive Building

An interesting description of the works of Messrs. W. G. Bagnall Ltd., Stafford

In the following brief notes we give an outline of the works of Messrs. W. G. Bagnall Ltd., Castle Engine Works, Stafford, England, one of the best known firms of locomotive builders in Great Britain.

The products of these works are not by any means unknown in India, the firm having supplied a large number of locomotives of the first class for the Bengal North-Western and Rohilkund and Kumaon Railways of India, and other locomotives to the Bombay, Baroda and Central Indian Railways. In addition, this firm's products are known practically all over the world where railway transport is called for.

In addition to the manufacture of locomotives, however, they specialise in side tipping wagons, steel sleepers, railway points, and associated products.

Extent of the Works

Some idea of the extent of the works may be gathered from the fact that the shops stand on a site of eight acres, which consist of five acres of buildings.

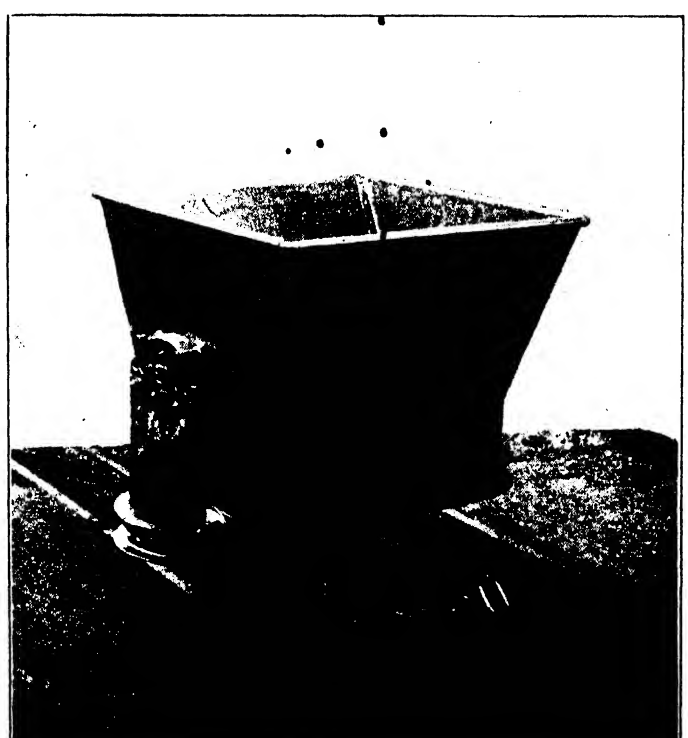
These buildings are laid out in accordance with the experience of modern practice, and are designed to give every facility for the efficient handling of the products of the firm. The whole of the buildings are well lighted both naturally and artificially, and are supplied throughout with a positive system of air warming for the winter months, the same system, of course, being utilised in the summer time for a constant supply of fresh cool air throughout the works.

The main erecting shop has been specially designed for the efficient assembling of locomotives, and adjoining one side is the fitting bay which runs the whole length of the shop. On the other side is the machine shop, and adjoining, but in a central position, is the tool room, and it will be obvious that this arrangement must be a very convenient and efficient one for the easy handling of the many parts which complete the locomotive.

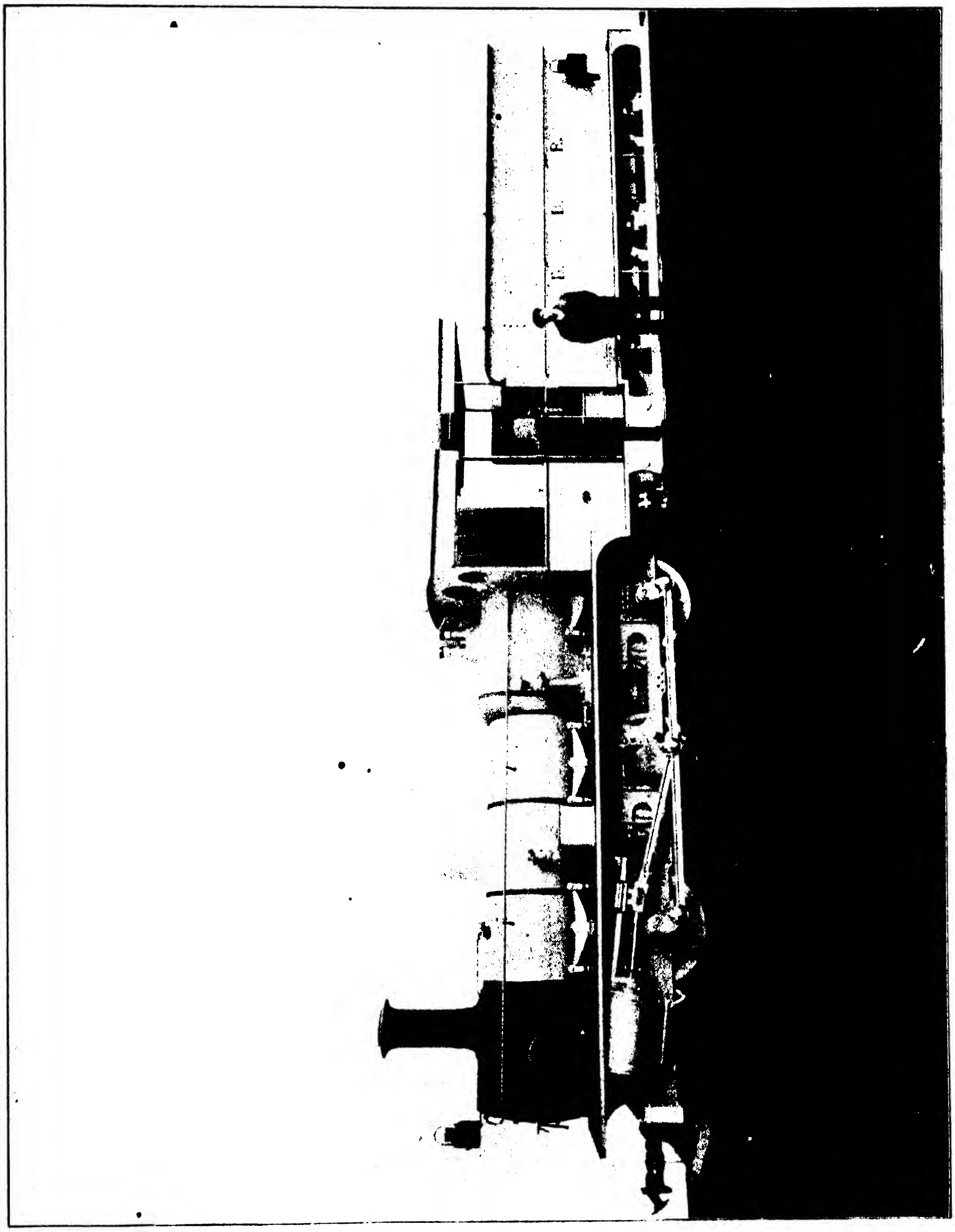
The tool room is very completely equipped, and is of sufficient capacity for producing the whole of the tools used in the works. This, again, is a feature of modern machine shops which is of the greatest importance if high-class work is to be carried out with speed and accuracy.

The iron and brass foundries are completely equipped for making all the different castings required by the firm, and here again, these shops are fitted with all the necessary mechanical appliances for rapid and efficient work, such as overhead cranes, ramming machines, etc.

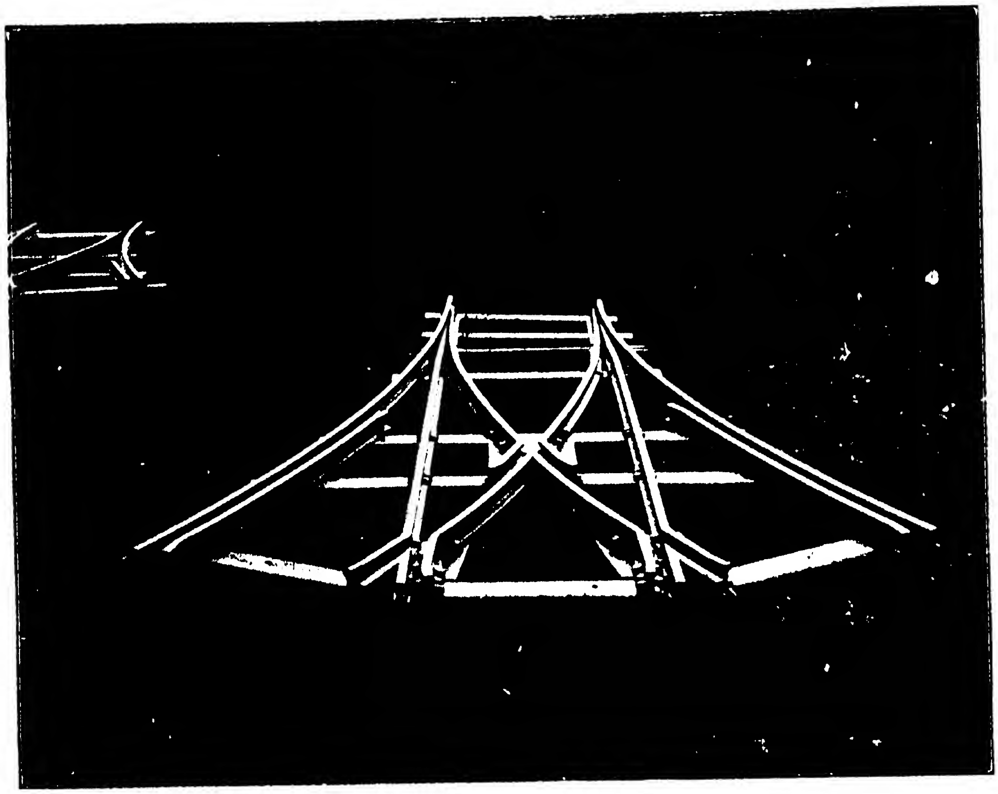
The equipment of the boiler shop includes radial and horizontal drilling machines, cranes, presses, pneumatic hammers, and riveters, and also a modern oxy-acetylene welding plant. The installation of most of these items is clear evidence of the up-to-dateness in this particular department. In the machine shop proper both light and heavy tools are installed, and they are arranged in such a manner that all similar tools are grouped together, such as lathes, planing machines, milling, and drilling machines, etc. In practically each case, one group of machines forms a bay in itself, which makes a very nice and symmetrical arrangement and has obvious conveniences.



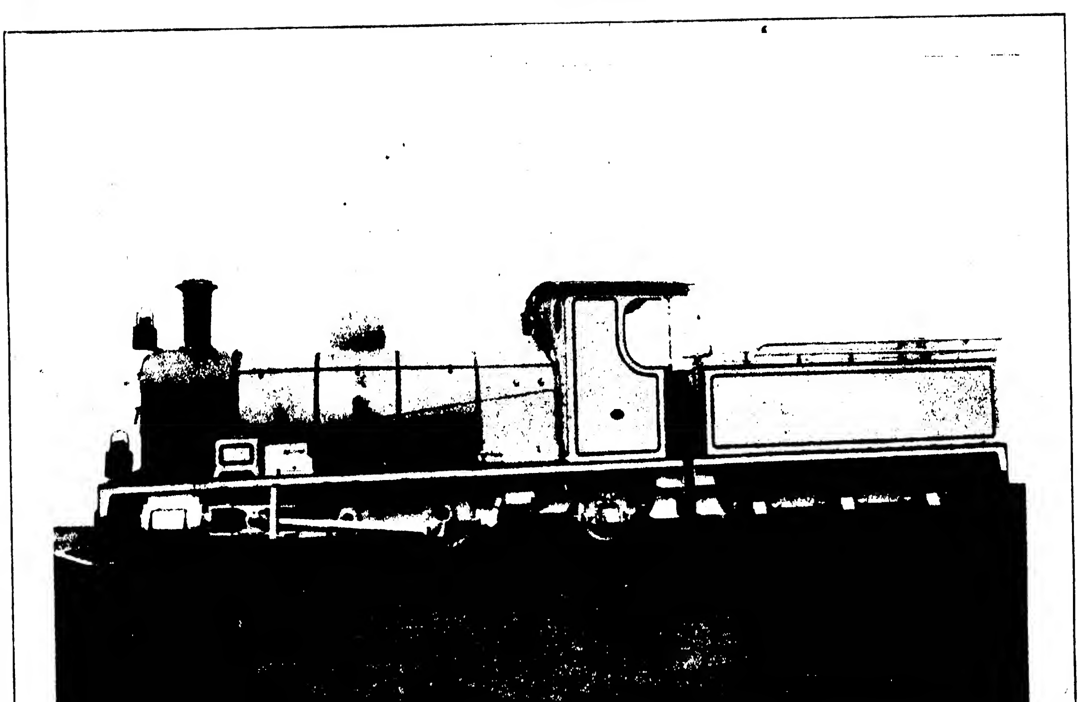
l-round Tipping Wagon



Metre-guage Locomotive for Bengal and North Western and Rohilkund and Kumaon Railways

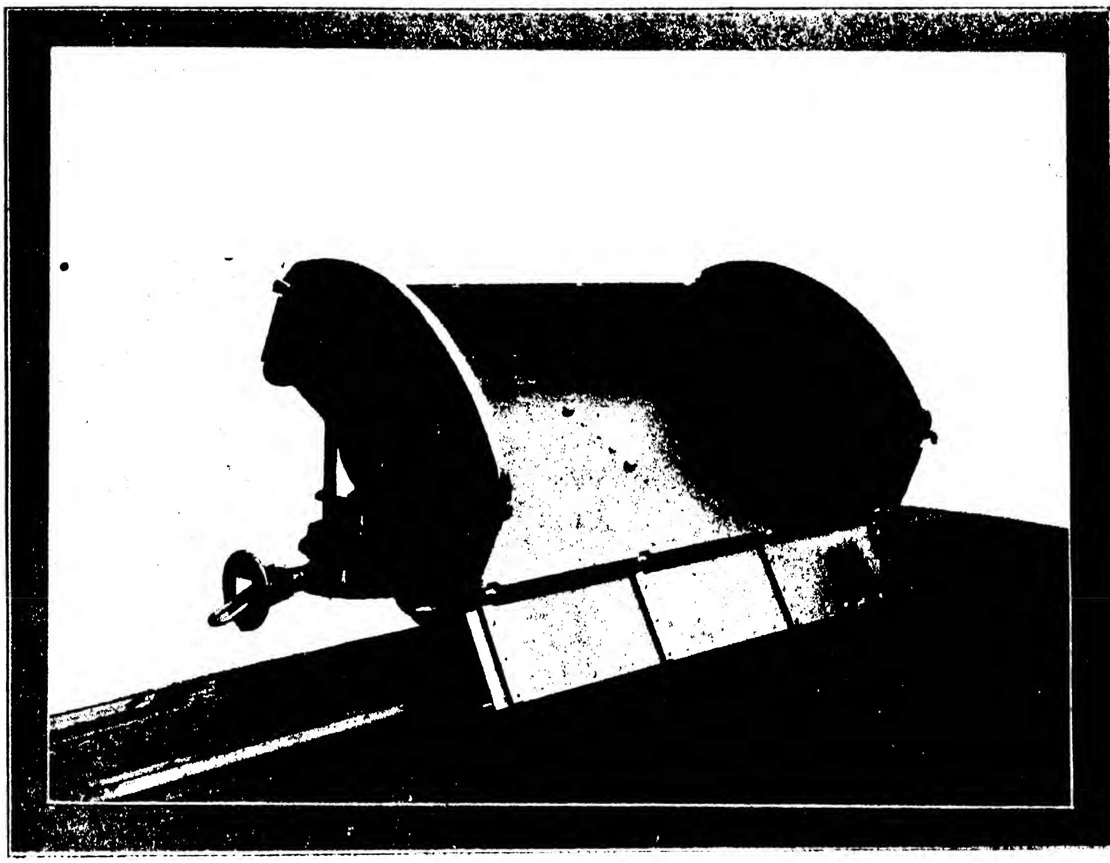


Three-way Switch



"W" Class Locomotive for Bombay, Baroda and Central Indian Railways

Other departments include the well-equipped pattern shop, special brass finishing shops, case hardening shop, smithy, and, of course, a very extensive stores department.



Square top Tipping Wagon

The actual products of this firm do not call for any detailed attention in this brief summary of the works itself, but our illustrations give a clear idea of the class and quality of work turned out by this firm, and, as we have already recorded, their locomotives are known throughout the industrial world.

There is one other point to which we would draw special attention, namely, that the firm have not only gradually kept their whole plant abreast of the times for specialised manufacture, but it has also been their aim to meet any special demands which were made upon them in relation to transport plant, and this is a point well worth keeping in mind by overseas buyers, as there are so many cases in which special problems are involved, and it is not every firm which is equipped on modern reproduction lines which is specially prepared to accept instructions for building special plant.

An Electric Train Recorder

A simple and ingenious instrument for checking train movements was recently devised for an overseas railway by a British firm. A record is automatically made on a horizontal drum which is driven by a clock. A long screw in front of the drum moves a pen slowly across the paper wound over the drum, and this pen carrier is controlled by electric magnets which are operated by the train as it passes over a special contact on the track. As each train passes this point, the magnet pulls the pen in one direction or another, according to the train movement. The diagram thus gives a continuous record of the trains passing a particular point in both directions. One advantage of this instrument is that it may be placed at any convenient spot away from the track.

Recent Machine Tool Developments
for Railway Workshops

In the following article we give some of the leading details of a new Railway Wheel Lathe, and Pneumatic Riveter for locomotive boiler work. These two machines are sold by Messrs. Alfred Herbert Ltd., of Coventry, to whom we are indebted for the loan of all the blocks used for the illustrations.

THE turning of railway wheels has developed into a fine art in that the modern lathe used for this purpose has been carefully thought out step by step as a result of practical experience, and as will be seen from the description below, every little detail has been specially designed with the object of convenience and speed of handling, the result aimed at being to complete the work at the lowest possible cost.

This new railway wheel lathe has been developed by Messrs. Alfred Herbert Ltd., in collaboration with Messrs. Noble & Lund, who are the actual builders of the machine. The first and experimental machine was supplied some little time ago to the Cowlairs Works of the North British Railway, and the firm's railway expert has recently been up at these works to discuss its performance on various classes of work, and we understand that the North British Railway management are extremely well pleased with the machine. They have given the following particulars of its performance :-

The machine is being used for returning worn wagon wheels, and the average production obtained continuously is 16 pairs per 8 hours. The rigidity of the machine is indicated by the life of the cutting tools. We are informed that the rough turning tools tipped with high-speed steel turn an average of 80 pairs of wheels before regrinding, while the full breadth form tools used for finishing last approximately a month without being reground, during which time about 400 pairs of wheels are dealt with. This, we think, is a point that will very strongly appeal to every railway shop manager.

Another special feature which the users are pleased with is the elimination of tool changing during operations, as will be noted from the description that both the roughing and finishing tools are secured in the tool rest together, and are brought into cutting position by movement of the tool-holder, thus the only time that the tools need be unclamped is for re-grinding.

The machine under discussion has a capacity of 30 in. to 48 in. diameter, but the firm are now designing machines for dealing with locomotive driving wheels, and having a capacity of 90 in. diameter.

In a recent test, several pairs of 36 in. wagon wheels were returned in a floor to floor time of 18 to 20 minutes. The amount of metal removed varied from ⅜ in. to ⅞ in. on the diameter. The treads and the tops of the flanges were rough turned with a coarse feed, the finishing being accomplished with form tools the full width, including flange.

The bed is a box casting weighing twelve tons, and is 30 in. deep by 22 ft. long by 5 ft. 8 in. wide at the driving headstock end. The great width provides a very rigid support for the headstock.

The drive is 50 H.P. variable speed motor mounted on the top of the fast headstock, and direct connected to the headstock gearing. Two speed changes are obtainable by sliding gears, which, in combination with the variable speed motor, give a wide range of speeds.

Push button control enables hard spots on the tyre to be machined at a slower speed than the remainder of the periphery. The motor can thus be started or stopped, or the speed varied as required without the operator moving away from the tool rests.

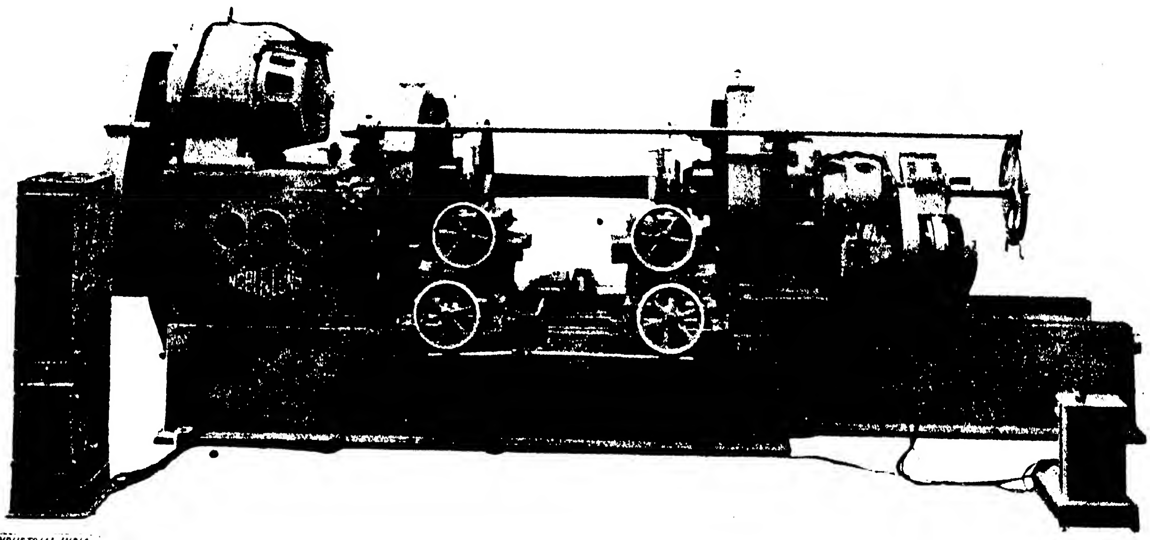
The driving shaft is of chrome nickel steel of large diameter, heat treated to resist torsion, and is supported by four bearings, one being between the two face plates.

The main spindles are of a special quality close-grained cast iron, and unusually large. Thrust is taken against the back of the headstock on special gun-metal plates arranged with a series of pockets, which, as the plates revolve in an oil bath, automatically lubricate the faces. Heavy face-plates driven by cast-steel, machine-cut, double-helical gears are bolted to the spindle flanges. The wheels are driven by four dogs on each face-plate. These dogs are of hardened steel, have serrated teeth, are compensating, and automatically adjust themselves to the tyre under the cut. They cannot slip.

The main spindles are fitted with internal steel sleeves, which are used as push-out collet chucks, the wheels being centred by the grip exerted upon the axle journals, which are fitted with split C.I. liners. Adjustment of the sleeves is effected by large hand wheels at the ends of the machine. To facilitate handling when a run of wheels of the same axle dimensions is undertaken, these sleeves are spring impressed, thus reducing the adjustment to an absolute minimum.

The feed motion is obtained by a pair of bevel gears mounted on the main driving shaft, close to the centre bearing. A shaft is disposed therefrom across the bed between the two tool rests. At the opposite end of this shaft is mounted a small crank disc, which, by means of rods and levers, actuates a ratchet motion on each tool rest.

The feed can be quickly varied by revolving a slipper plate, which allows the ratchet pawl to advance the feed screw at six different rates. The feed is geared up to move the tool rest six times per revolution. The facility with which the feed can be varied on either tool rest is very valuable when obstinate tyres are met with.



Heavy Duty 48-in. Railway Wheel Lathe

The clamping of the tailstock is effected automatically by wedge projections on the front of the tailstock, which are forced into pockets on the saddle and the rear slide of the bed. The tailstock is traversed by a 7½ H.P. reversing motor operating through specially designed friction clutch and train of gears to a revolving nut working on a fixed screw in the bed. This mechanism is mounted on the tailstock itself, thus saving floor space and keeping the motor out of the dirt it is usually covered with when fixing at the end of the bed.

The design of the tool rests has had special consideration, and they have been made very massive to resist the heavy cutting strain.

They are arranged to swivel to suit any angle of wheel tread, and fitted with a bottom slide which can be moved to suit varying diameters of wheels. The top sides are steel castings arranged to carry roughing and forming tools side by side, which tools are held by powerful toggle levers. By this arrangement tool changing is eliminated, except for re-grinding.

The form tool and holder are of special design, as shown by sketch.

Each rest is provided with a graduated scale and adjustable pointer, enabling the same depth of cut to be put on each wheel without measurement.

The lathe is fitted with a trammel bar for comparing the size of each wheel in a pair.

All gears are of high tensile steel, with the exception of the motor reduction gears, which are of cast iron with raw hide pinions.

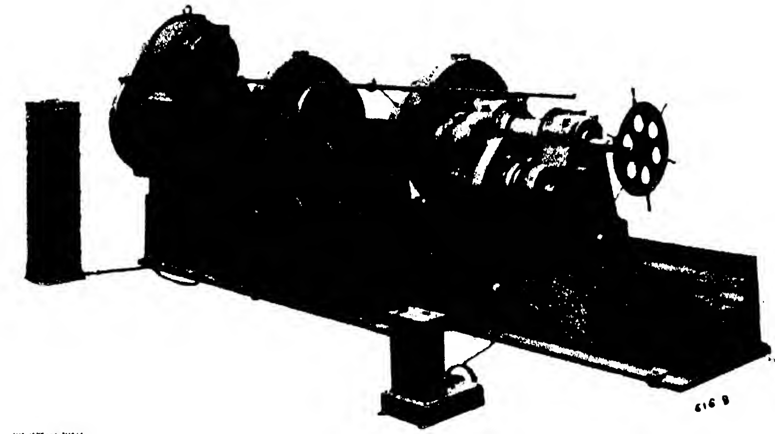
The equipment includes one pair of collets bored to suit any specified diameter of axle, one set of tools (comprising two high-speed steel roughing tools) and two form tool holders complete with high-speed steel blades and necessary spanners.

A self-contained hoist fitted with an electric pulley block for raising wheels to the centres can be supplied at extra cost.

Vulcan Pneumatic Riveter

Turning to the description of the Vulcan patent pneumatic riveter, this machine has been evolved to overcome one of the principal difficulties in the handling of pneumatic tools, namely, the great weight which has to be operated by the physical efforts of the workman himself. This machine was, therefore, designed to do away with this, and the only work that the operator is called upon to perform is to set the two hammers in correct relation to each other to operate the air valve and to rotate the snap during the riveting operation.

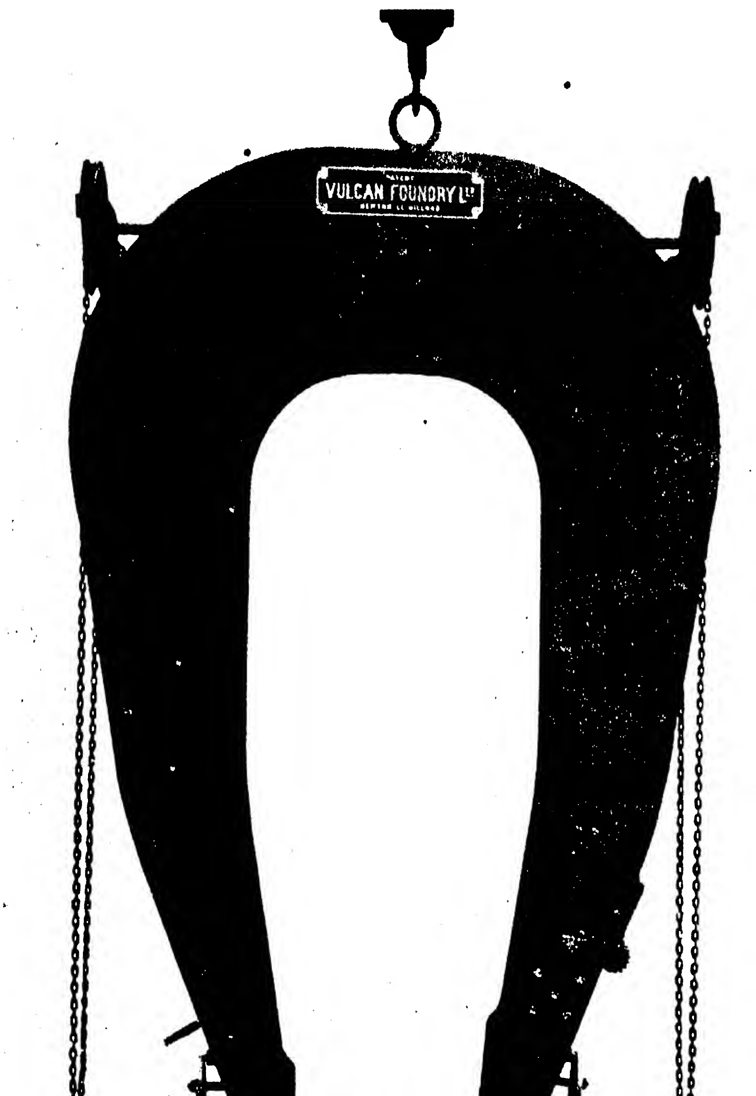
The type of snap used in this riveter calls for special mention. It is not a plain cup-shaped piece of metal, but has three ribs joined in the centre and merging into a continuous ring of metal on the rim.



View showing method for quickly changing the tools

With this type of snap a better spreading action is obtained, but it becomes necessary for the operator to rotate the snap during the operation

All locomotive boilers made by the Vulcan Foundry, at Newton-le-Willows, are riveted with this apparatus, and their reliability is a strong testimony to the value of this method of riveting. The apparatus is also in use at many of the other private locomotive firms in England and other countries, as well as a few of the Railway Companies.



Vulcan Patent Pneumatic Riveter

This riveter has been designed to improve and cheapen the riveting of copper and steel firebox stays, and is suitable for any type of boiler. The employment of four men out of a gang of six is obviated where the usual practice of two strikers and a holder-up to lay over one head obtains.

Method of Working

The Vulcan riveter forms two heads (*i.e.*, one on each end of the stay), simultaneously, and in less than half the time required to lay over one end by hand. It is well known that the life of a stay depends on its conductivity, ensuing from a close contact between the heads and plates and the non-distortion of the threads and plates. It is also highly desirable that the heads should be of a uniform size and shape, and should offer no edges to the destructive influence of the hot gases and other abrasive matter.

By the older methods of stay riveting it was necessary after forming the head at one end of the stay, to hold up against it. This, of a necessity, caused distress to the metal, and loosened the threads at the finished end. The Vulcan riveter entirely eliminates this "holding up" operation.

Up to the present time pneumatic stay riveting has not been adopted to any great extent, owing to the fatigue caused to the workman by having to carry the weight of the hammer and hose, to supply the requisite energy for holding up against the stay during the formation of the head, and having to absorb the vibration and other strains set up thereby. It will be seen from the illustration of the machine that all these strains are absorbed in the yoke itself.

The attachment used in conjunction with the machine is in the form of a snap, but instead of being cupped in the usual way, it is provided with ribs which merge into a continuous ring just when the tool is brought into contact with the plate. By a slight oscillating movement imparted to the tool by hand, the first blow tends to spread the metal, and as the riveting proceeds, a larger surface of

the stay is automatically brought into contact with the ribs and continuous rim, and the weight of the blow is thereby decreased in that ideal graduation which is necessary for the formation of a perfect head and finish.

The pneumatic hammers, which are of special construction, are mounted in breeches in such a way as to be instantly removable in the unlikely event of a breakdown, by simply unscrewing the lock nuts.

The hammers can be set and locked at any desired angle by a worm gear and locking device. The machine is also provided with a worm gear, which enables the operator to sling it in any desired position, and which makes it possible to undertake any class of work without difficulty.

The boiler is turned on its back for operating, and the yoke lowered into position. A man is stationed at each hammer, which he screws up against the stay by means of the levers. The hammers are then set to work by pressing the throttle valve rod, and, at the same time, the cups are rotated through approximately 100 deg. to 180 deg. by their handles. As the heads are formed, the hammers are moved forward up to the plate until the operation is completed. In the event of one head being formed before the other, a sufficient "holding up" pressure is maintained by the idle hammer while its cup is still being rotated.

The equipment consists of a yoke and the necessary fittings, and two specially constructed pneumatic hammers complete with cups to suit the diameters of the stays, which should be specified when ordering.

It is advisable to keep a few spare cups of various sizes, and a spare hammer for each machine.

To obtain the best result in slinging, it is necessary to sling the riveter from a suitable crane to give freedom of movement and ease of operation

Vestibules or Flexible Gangways

for Railway Rolling Stock

The vestibules described in this article are manufactured by the patentees, Messrs. Beckett, Laycock and Watkinson Limited, London, under their trade mark "Beclawat."

WITH the increasing demand for corridor coaches to meet modern conditions, there has arisen a consequent call for vestibule connections or flexible gangway connections for use in conjunction with same.

At the present time there are various designs of the latter, adapted to suit particular coach-ends, but these may be classed, with modifications, under two headings—the angle frame pattern, and the flush or frictional face plate type.

The illustrations shown in this article are two styles of the former. It will be seen that these vestibules are clamped together by hand, and the clamp held in position by a link and shackle.

That illustrated in Fig. 2 is of the frictional face plate contact type, and instead of being coupled by hand, this is performed automatically, the face plates of opposing vestibules being held in frictional contact by overhead piston rods and compression springs, and below by buffer stems and compression springs.

The Diaphragm

One of the most important factors in the efficiency of a flexible gangway connection is the diaphragm, and in the Beclawat design the chief feature is its sloping top and corners, made from fire-, water-, and acid-proof canvas which will not allow the accumulation of cinders or water. The folding action of the sloping top and corners is made along a straight line, which prevents wear and the subsequent bursting at these points. The diaphragm is in two sections, the adjoining edges being stitched together, and the seam strengthened by a one-piece angle iron frame on one side and a flat strip on the other, the whole being riveted together with japanned brass rivets, or it is sometimes wired. This angle truss serves to retain the diaphragm in its correct shape, prevents sagging, and protects seam edge from the weather.

All joints at top and edges stitched and bound with leather; the feet bound with chrome leather prevents wear and splitting. This diaphragm can be supplied to fit any coach frame, and with extra folds if desired.

In Fig. 1 is illustrated a form of the hook and shackle type vestibule, which is suitable for the smaller style of rolling stock. The face plate consists of a one-piece angle iron frame lined with ash strips, to which one end of the canvas diaphragm, of the plain loose hanging type, is securely fixed. The other end of the diaphragm is fastened to an ash frame, being bolted to the inside of opening in coach end.

This vestibule is protected against cinders and water by a separate chrome leather hood covering the top, bolted to the front and rear frames.

The latter are connected by two leather encased tension springs fitted inside at the top corners, which act as centralisers in working. A hook is attached to the front angle, and

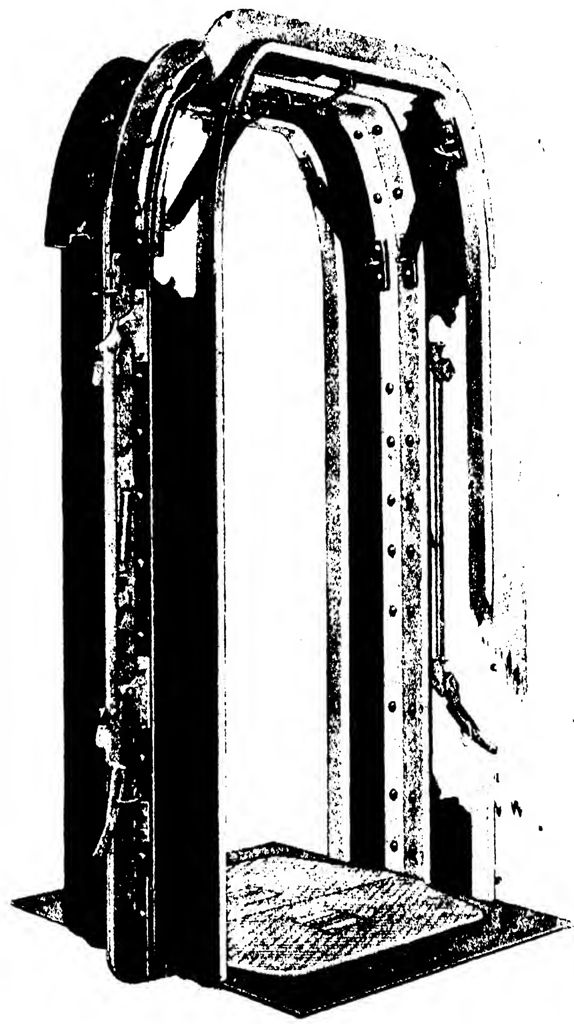


Fig. 1

when the latter is pushed back, engages in an eye on the coach end, retaining vestibule in that position. The top chequered foot plate is fitted with a hinged trap door which permits access to the coach coupling lock while vestibules are connected. The angle frames of two opposing vestibules are clamped at both top and bottom, one movement of the hand lever operating both clamps.

We show in Fig. 2 what is known as the Pullman type of vestibule, and is preferable for the heavier type of railway coach.

The face plate is perfectly flush on the front side, and is held in frictional contact with the opposing

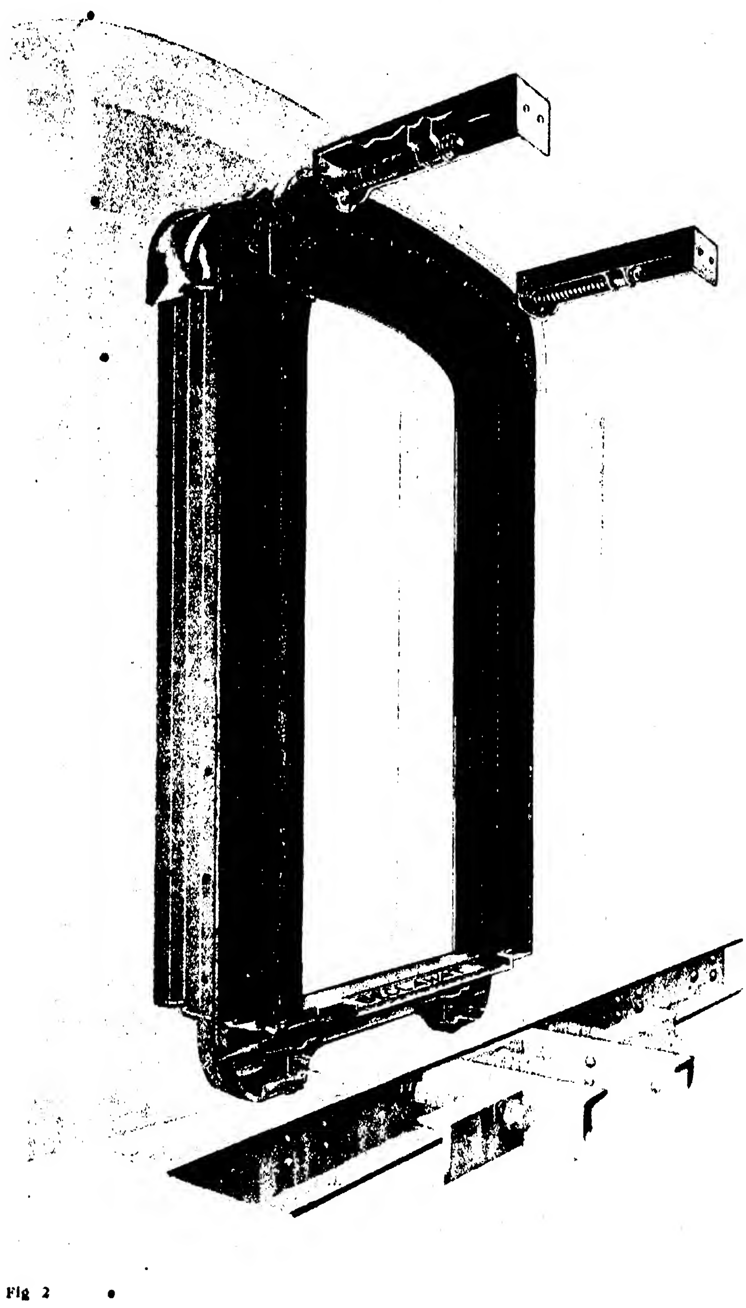


Fig 2

vestibule by overhead piston rods and compression springs housed in suitable boxes which are firmly fitted to the coach woodwork, the vestibule end of pistons having a ball and socket connection facilitating free movement when coaches are negotiating curves.

The lower buffer stems are connected to the buffer face plate by means of a hinge bolt, the rear end of the compression springs usually abutting on a compensating beam which serves to centralise the vestibule under all running conditions.

The diaphragm is of the vee-section type, and consists of canvas strips sewn together at the edges, the top corners being separate, stitched to sides and top, and joints bound with leather.

A chequered foot plate is supplied to suit coach end frame work.

The Electrification of English Main Line Railways

(Continued from page 225.)

MR. J. A. HOOKMAN (Locomotive Engineer, North Staffordshire Railway) remarked that he did not understand what was meant by not pooling steam locotives; as far as his experience went, everybody pooled engines. The man only worked for eight hours, but the engine for twenty hours. He disagreed with the statement that one hour was allowed for getting the engines ready, he thought thirty-five minutes was about the average time usually allowed.

The advantages claimed for electric working might be placed under four main heads:—(1) Great reserve of power, giving much higher acceleration, also greater speed on rising gradients; (2) convenience of dealing with trains at terminal stations, and avoidance of necessity for turning engines; (3) practically no time required for engine duties, and none for taking coal and water, so that the same traffic could be worked with fewer engines and fewer men; (4) actual economy in cost of producing the power required and in repairs and maintenance. Higher rate of acceleration and a greater reserve of power were possible with electric motors than with the average locomotive of the present day. Although terminal working had been much improved by electrification, it did not appear that the best was attempted previously with steam. A great portion of the life of a steam locomotive was—from a revenue-earning point of view—wasted, and the number of electric motors required to work a given traffic was considerably less than the number of steam locomotives. The London, Brighton and South Coast Railway's South London line showed a reduction of 46 per cent. in numbers of motors compared with number of steam locomotives, with a more frequent service.

Power could be generated more cheaply in up-to-date power-stations than in locomotive furnaces. The following figures were given at a meeting of the Institution of Locomotive Engineers:—2 lb. of coal in power-station to produce 1 B.O.T. unit; efficiency of transmission of power to draw-bar, 62 per cent.; giving 3.2 lb. of coal per B.O.T. unit, or 2.4 lb. per H.P. per hour at draw-bar. For the ordinary steam locomotive the figure varied from 4 lb. to 8 lb. per H.P. per hour at draw-bar. The steam locomotive required constant inspection, and many small repairs had to be done in the running shed, and shop repairs every 20,000 to 100,000 miles, according to class. It was claimed that the electric locomotive required very little inspection and few light repairs, but the first cost was greater, and life probably less than the steam locomotive, for which thirty years was quite a reasonable average. Again, adding the cost of repairs to the machinery at power-stations and sub-stations, and the maintenance of the conductors, it was, to say the least, doubtful whether experience would show any saving on the maintenance side. The higher acceleration obtained with electric locomotives was of very small value on long runs, though all important where the stops were frequent, but the great reserve of power, and the capacity of a motor to work at a considerable overload for some time, enabled a greater speed to be attained on an up-grade than with the steam locomotive, and thus increased the average speed.

An objection raised against electrification was that a whole section might be thrown out of use, and the traffic stopped, but it had not proved a very real difficulty. One advantage of electrification was the possibility of using regenerative braking—saving power and brake-blocks, which varied in importance according to the contour of the line. The cost of brake-blocks on a certain railway equalled 2½ per cent. of the fuel bill—pre-war 4 per cent. to 5 per cent.; part of this would be saved. It was possible that further improvements in steam locomotives, or the development of the internal-combustion engine, might alter the whole aspect of affairs before many years were past, thus avoiding the large capital outlay required for root-and-branch electrification.

Mr. C. F. Bengough (Chief Engineer, North Eastern Railway) said that a very interesting paper had recently been read by Sir Vincent Raven dealing with the electric locomotive. He emphasised the fact that the electric locomotive consumed no fuel when it was not doing work; and he pointed out that a steam-engine on the North Eastern Railway occupied 25 per cent. of the enginemen's total time in ineffective locomotive duties. He also referred to the fact that coal could be much more efficiently burnt at the power-station than in the fire-box of a steam locomotive. On the Shildon-Newport line the cost of repairing the electric locomotive was 1.316d. per mile, and steam locomotive 5d. in one case, and 5.522d. in another. There was a great deal to be said for electrification, provided the necessary power could be obtained at a cheap rate. To convey the electric current to the train, the alternatives were an overhead wire or a third rail. In the case of a line electrified on the third-rail system, in order to make the sidings safe for shunters to work, the third rail would have to be very fully protected, and would form a very serious obstruction.

Overhead equipment would appear to be the only practical form where shunting had to be carried on. The disadvantages of the third rail were increased difficulty in maintaining the track, whilst in the case of derailment occurring on the third-rail side, a comparatively slight displacement of a vehicle would wreck the third rail. The main advantage of the third rail was its accessibility. On the other hand, to carry out any repairs to the third rail the current must be cut off. The overhead equipment was an obstruction to the working of breakdown cranes in the case of an accident, and heavy gales caused the contact wire to be blown off the engine bows. But the maintainence of the track was not interfered with, and could be carried out by the platelayers without any risk of accident.

In the electrification of the portion of the North Eastern main line, which was under consideration, it was proposed to employ a pressure of 1,500 volts, and the best protected third-rail. The three forms were the top-contact, such as was used on all

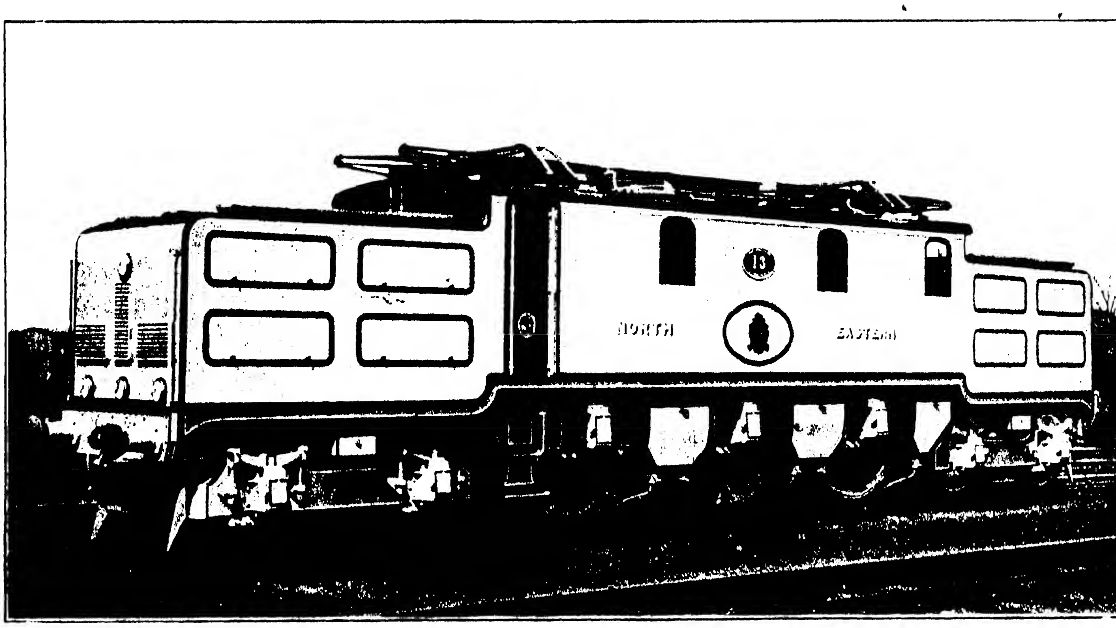
the third-rail system in England, except the Lancashire and Yorkshire Manchester and Bury (1,200 volts) —where Mr. Aspinall's side-contact was in use; and the under-contact, which had not been used in England, but was in use in America, with which the most complete form of protection could be obtained, and the rail was most fully protected from ice and snow. With the under-contact system, however, there was some difficulty in providing the necessary clearances between the top of the protection and the underside of the load gauge, and between the underside of the collecting shoe on the engine and the running rails. Experiments were made on the Shildon-Newport line with a length of third-rail fully protected with wood, and with another covered with a bituminous compound. The compound appeared to be the better insulator of the two, but with the wood and the compound in wet weather, with 1,500 volts pressure, one would get a very heavy shock. The balance of advantage he thought was with overhead equipment.

On the Shildon-Newport line the gantries for carrying the overhead wires were composed of steel sections. The normal distance between the supports was 109 yards (100 metres), and this span, on some of the expcsed parts of the line, had been found to be too long. There were five wires for each track, namely, catenary, auxiliary, two contact wires, and one feed-wire. A cheap and efficient form of equipment for long stretches of track in the country, where it was only necessary to span two lines, was with supports formed of telegraph poles connected by a beam, formed of channel sections, for carrying the wires. Telegraph poles were, of course, largely used for this purpose in the States and on the Heysham-Lancaster line, Midland Railway. Part of the Shildon-Newport line was equipped with only one contact-wire, and from their experience they had come to the conclusion that this was all that was necessary. There also seemed to be no reason why the catenary should not be used as a feed-wire. With this type of construction he estimated a line could be equipped quite as cheaply as with third-rail, and the maintenance costs showed a considerable balance in favour of the overhead.

Mr. F. W. Carter (British Thomson-Houston Co., Rugby) said methods of working which had grown up around the steam locomotive were subject to the limitations imposed by it, and electrical operation would conform to its limitations also. Estimates of performance and expense based on steam traffic should improve with methods suitable to the new motive power, and estimates based on conditions unfavourable to change might be upset by experience of new conditions.

Mr. Harold Holcroft (S.E. & C.R.) wrote that the repairs of the transmission line and track equipment should be charged against the electric locomotive, and the cost of running it compared not with engines thirty years old, but with modern engines. The steam locomotive was an independent unit, not easily put out of action by aircraft or strikers. The adoption of electric traction would bar the way to the use of an internal-combustion engine, which needed only a suitable transmission gear to make it effective.

Dr. F. C. Lea said the steam-locomotive could not be increased in height or width, nor the boiler or cylinders made larger, while its weight and axle loads were limited by the cross girders of the bridges. Seventy-five per cent. of the weight of the electric locomotive could be on the driving axles, but only 60 per cent. of the weight of the steam-locomotive and tender. Portions of the weights of the reciprocating masses of the steam-locomotives could not be balanced in a vertical direction, and at high speeds set up additional stresses in cross girders. There need not be any reciprocating masses in electric locomotives. The steam-loco-



Electric Locomotive to haul a 450-ton express passenger train, average speed 65 miles per hour

Equipped by Metropolitan-Vickers Electrical Co. Ltd.

1,200 H.P. Metropolitan Railway Electric Locomotive

Metropolitan-Vickers Electrical Co. Ltd.

motive had reached the limit of its power without heavy expenditure on the bridges, but electric locomotives could produce higher tractive force, and handle heavier trains at better mean speeds over existing structures. Against the heavy capital expenditure necessary for conversion to electric traction, there would be many assets, besides those arising from economy in fuel and wages.

Mr. A. M. Taylor said the cost of energy was all-important, and some large stations were producing it at a works cost as low as 0.2d. per unit. The current so obtained must then be transmitted over long distances demanding high voltage. If 100,000 volts were used in place of 3,000 volts, the cost of copper would be enormously reduced.

Mr. Alfred Dickinson thought most of those who had had any experience in the building of hydro-electric plant realised that such plant was not built for nothing. The capital cost must be taken into consideration. There were many reasons why hydro-electric power would not be very successful in England; one was the cost of land. It was not possible to have a hydro-electric power station under 20,000 H.P. which would pay its working costs in England. He believed the application of modern methods in the better utilisation of fuel was going to be their salvation.

Mr. R. A. Chattock (Electrical Engineer for the City of Birmingham) said that, from the point of view of the electric power-station, a railway load was a valuable one, because it gave a high load-factor. That would be a benefit not only to the industrial supply from the station, but also to the railway supply itself. If the power-station could be operated with a high load-factor, he thought it should be able to supply current at a lower figure than that quoted by Mr. Smith. The fear had been expressed that it would not pay to electrify the main lines of railways. Electrification which had taken place so far on suburban lines, had, they were told, attracted an increased amount of traffic. The only way in which it could attract additional traffic was to make the traffic cheaper or easier. It had done so on the suburban lines; why should not the same thing happen on the main railway lines both for passenger and goods traffic? These points had not been sufficiently emphasised, and they were very important ones in considering the question of the electrification of main lines.

Professor F. W. Burstall said many engineers were familiar with Messrs. Sulzer's experiment twelve or fourteen years ago. Mr. Burn read a paper on 6th January last at the North-East Coast Institution of Engineers and Shipbuilders; in which he advocated combining a direct drive from a Diesel engine with compressed air for providing the starting torque. It might be worth while investigating this, before the country embarked on costly schemes for electrification.

Professor William Cramp, D.Sc., said speakers had taken it for granted that the traffic on the main lines was to be similar, under electrification schemes, to that which existed to-day. That, to his mind, was to start absolutely at the wrong end. The distances between large towns in England were, after all, only suburban traffic distances, and what was wanted was short trains of high acceleration and high frequency. That was where the railway engineer should start in electrification, if he wished to make the main lines of England a success. If the railway engineer would start with all the advantages of electric traction, with shorter trains, high acceleration, and great frequency, he would make the thing a success from the outset. Having regard to foreign experience, some of them were dismayed at the decisions which had been arrived at by the Railway Commissioners with regard to their recommendations as to transmission and distribution of electric power. The 1,500-volt direct current might be a success, but this was not the time to lay down such a hard and fast regulation. They should have far more elasticity and discussion before they were limited in that way.

Dr. Gisbert Kapp said that, considering three-phase locomotives, these weighed only 60 tons, and developed 2,000 H.P. No steam-locomotive could come anywhere near it. A line had been at work successfully abroad for twenty years on this system, which had been adopted by the Italian Government for the Mont Cenis line. This system enabled a very great density of traffic to be handled, whilst great tractive power could be utilised, and old bridges could be used without the necessity of strengthening them. This accounted for the enormous traffic which the line was able to carry during the war period, especially in 1917, the traffic in mileage being trebled in comparison with pre-war conditions. But it had disadvantages. One was the lower power-factor when running in cascade; it was now in course of improvement by putting phase-advancers on the locomotives.

He wished to emphasise the advantages of single-phase alternating current of low periodicity. He was pleased to hear one speaker say that, on the whole, the overhead wire was preferable. He also mentioned that the tendency seemed to be to use 1,500-volt direct current. With 1,500 volts they would not go far; modern electrical firms would be prepared to supply motors up to 600 and 800 H.P.,

which would work with 3,000 volts direct current, but 3,000 volts would necessitate sub-stations all along the line. It was no use going in for half-measures in that way. If they compared 3,000 volts with 15,000 volts on an overhead wire, they would find the diameter of the wire need only be half in the latter case with one-fourth the area, whilst the sub-stations could be ten times as far apart. The sub-stations were simply static transformers which required no permanent supervision. For direct current, three-phase transmission was recommended. Inside the sub-stations they must have transformers, converters, and a considerable staff. It was true that in America they had automatic apparatus, but he did not think in England they would trust it. It would be a mistake to think that they could save a maximum amount of labour by using automatic apparatus. They could save labour by arranging for such plant that it would not require to be looked after, and that was the way the Swiss were arranging in the Gothard line. There they were working on 15,000 volts, 16⅔ periodicity.

With regard to the question of transmitting electric power, Professor Kapp pointed out that at the present time in Switzerland they transmitted the electric power partly overhead at 15,000 volts, and partly by cable at 60,000. He did not think they could do 50,000 volts transmission in England by overhead wire, but they could use 60,000 volts by cable. The Swiss cable was a single core, 14.4 mm. diameter; the di-electric thickness being little over ½ inch. A 15,000 volts transmission overhead along a railway would be no danger, because it would be on the Company's own ground, and there was no reason why the installation should fall down and injure anyone. The objections would be the same with all transmissions; and it did not matter whether one was killed with 15,000 or 5,000 volts.

In conclusion, he expressed the hope that whatever system was adopted, it would only be done after very careful consideration, because once they had adopted a system they could not change it. Moreover, they could not contemplate the possibility of every railway having its own different system. They might have different details; he would not advocate for one moment that they should stereotype any detail, which would kill the possibility of improvement; but what they could make uniform was the main principle, namely, low periodicity, high voltage, and single phase.

Mr. C. V. A. Eley said the railways were the military roads of the country, and it was important they should not be put out of action by a bomb dropped in the generating station. He thought a locomotive might yet be designed to give an I.H.P. with 10 lb. of steam.

The Chairman, in summing up the discussion, welcomed the pertinent points raised by Dr. Kapp. There were many points with regard to the criticism of steam and electric locomotives which might be dealt with if there was time, but the consideration they wanted to lay hold upon was whether it was going to pay to electrify our main lines. There was no insuperable electrical or mechanical difficulty in the electrification of main lines, but there was a difficulty in regard to the financial side of the problem when they were dealing with a low density of traffic. He would again quote Mr. A. W. Gibbs, who said the difficulties were more mechanical than electrical. The electrical side of the problem seemed to be perfectly sound. There were certain mechanical difficulties. One of them, unfortunately, had not been touched upon, that was the question of low centre of gravity and wheel arrangement.

Welfare Superintendents and their Training

(*Continued from page 262.*)

While social workers require to supplement their practical experience with a knowledge of economic theory, students, on the other hand, require to supplement their theoretical knowledge with experience of actual conditions of work in factories. For this purpose it will be necessary to secure the goodwill of employers. The student should endeavour to get permission to take up the work of a man who is on leave. He may offer to enquire into the time-keeping of the various departments, and to interview late comers, but he should not ask to be given a post carrying with it disciplinary powers, nor should the post be a very responsible one, but it should be such as to bring him into personal contact with the workers. In addition to thus getting experience of factory conditions, the student should also undertake some form of social service work which will give him an insight into the living conditions of the workers.

Much can be done, and might well be undertaken by the Universities, both to create a demand for welfare workers and to supply it when the need has been recognised. Courses of lectures should be thrown open to the public dealing with the different aspects of welfare work in connection with factory management. Firms should be invited to allow the junior members of their staffs to attend such courses. Medical students and social workers should also be invited. The possibility of starting University training courses for social workers has already been discussed, but before any regular courses can be started, it is essential that a good deal of propaganda work should be done.

In England there are special University courses, combined with practical work, but in England there is a definite demand for welfare superintendents. Until this is the case in India, it is hoped that the tentative suggestion made in this paper may be considered by University authorities, factory managers and social workers.

INDUSTRIAL INDIA

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BETWEEN OURSELVES

The French Government Fuel Economy Report

THERE has just been published the Seventh Report of the Commission d'Utilisation du Combustible, which gives an interesting account of the methods being used in France with a view to obtaining increased economy in fuel, especially in connection with steam generation. It was soon discovered that the general design and management of French boiler plants was of a most inefficient and indifferent character, and in order to try and remedy this state of affairs, one of the proposals is to extend considerably the few schools in France where instruction can be given in the elements of efficient steam raising.

An account is also given of the improved methods that have been adopted in a number of the more prominent large works of France. At the Forges et Acieries de la Marine et d'Homécourt, a system is in vogue which includes the collecting of all the available data on steam generation, and the preparation of weekly reports of the performance of the boiler plants, together with a central advisory bureau in the factory. At Messrs. Schneiders' works, at Creusot, a very elaborate system is in vogue, with a special centralised staff to attend to the scientific side of the steam generation. This staff analyses all the fuel, and allocates it to the many different uses in the establishment, according to its qualities, besides keeping a close check on the consumption. At the same time, a bureau of information of every description in connection with steam generation is being accumulated. The boilers and generators are directly controlled by an operating staff, and this section has its own laboratories, etc., whilst there is also a very detailed system of premiums paid on results. It is stated that the result has been to reduce the coal consumption of the whole works 15%, an enormous figure for a huge establishment such as Creusot, whilst at the Breuil works of Messrs. Schneider, 14% has been saved by adopting similar scientific methods of control of twenty-eight suction gas producers.

One of the most interesting organisations in France for fuel economy is the Office Centrale de Chauffe Rationelle, Paris, established in 1919, and founded by various firms interested in marine coal, with the addition of a Government subsidy. This organisation, in the first place, has a school, which gives courses of five weeks' duration in fuel economy to engineers, and also has another less advanced course of four weeks for firemen. The Office acts further as a central bureau for data and information regarding fuel economy, and is prepared to design new power plants or reorganise existing ones. It also has a laboratory, and a small staff of engineers to carry out tests and investigations into the working of boiler plants, and, altogether, appears to be doing good work, in spite of its small size. There seems to be no question, however, that French boiler plants in general are not much more efficient than, for example, British, in spite of the fact that fuel is much more expensive and the water-tube boiler is much more largely used.

* * *

Boiler Plant Performance Figures of Dalmarnock Power Station

A particularly interesting analysis is given in the current number of *Engineering* of the results of the working of the new Dalmarnock (Glasgow) Electricity Station, to which we have referred in previous notes. The figures for this station are of great value, because, in the first place, Dalmarnock is one of the few large electricity stations in Great Britain really fitted with proper instruments and appliances for a system of continuous record taking per shift on the plant. Secondly, it is one of the very small number of stations that have published genuine records of the actual boiler plant performance week in and week out, and not ridiculous test figures taken for a few hours under purely abnormal conditions, so that results like 84 to 85% boiler plant efficiency are *not* being obtained.

There is no question that in a station of any size it is absolutely necessary, for the best results, to take the records of the water evaporated and the coal burnt in each boiler separately per shift, and to compare and plot the results with great care, so as to keep a proper check on the performance.

The figures now supplied with regard to Dalmarnock relate to 85 consecutive eight-hour shifts, varying from 30,000 to 230,000 K.W. hours per shift. In the first place, the total no-load losses are very good, amounting to about 20,000 lb. of coal per shift, 5,123 lb. to make up losses in the boiler plant, and 14,877 lb. for making steam which does no useful work, which, of course, includes all the loss due to radiation and condensation in the boiler and turbine room. As regards coal consumption, when the output is 50,000 K.W. hours, during the 8 hours the coal consumption averages 105,800 lb., or 2.116 lb. per K.W. hour, whilst on

a fuel output of 200,000 K.W. hours, the consumption was 363,200 lb., or 1.816 lb. per K.W. hour. The steam consumption of the station is 11.53 lb. per K.W. generated, the no-load consumption being 100,000 lb. steam per 8-hour shift. The water evaporated per lb. of coal on the 85 shifts works out at 6.722 lb., with an average heat value of 10,500 B.Th.U's. per lb., which, with feed-water going into the boilers at 141 deg. F., corresponds to an actual efficiency of 80.9%, a remarkably good figure, bearing in mind, as already stated, that these are genuine working shift figures. There are probably very few electricity stations in Great Britain, or anywhere else, that are actually working at over 77½%, and probably the average figure is less than 75%.

* * *

A Plant for Briquetting Iron Ore

Messrs. Sutcliffe, Speakman & Co. Ltd., of Leigh, have supplied to the famous Cockerill works at Seraing, Belgium, a plant for briquetting and calcining iron ore, to handle 150 tons of ore per 24 hours.

Messrs. Sutcliffe, Speakman have made a speciality for many years of high-pressure briquetting plant, and, as in the case of the "pure coal" briquettes, of which this firm own the patents, the iron ore is briquetted without any binding medium, using high pressure only. The plant includes two briquetting presses, each handling 6 to 8 tons of ore per hour, the briquettes being 7 in. × 7 in., and the ore is conveyed by small automatic mono rail buckets, screened, and delivered to an automatic feeder attached to the presses at exactly the rate required by the press. The briquettes, as they are automatically delivered by the presses, are stacked by hand on small wagons, piled two rows high, and arranged with a space between each briquette, so that the heating gases can pass freely round each briquette. The wagons carry 324 briquettes, weighing nearly 2 tons, and as each wagon is filled it passes to the door of the kiln, and is pushed in by a hydraulic ram, the wagons already inside moving forward by the length of the wagon, and a corresponding wagon of calcined briquettes being discharged at the other end. One wagon enters and leaves the kiln every 20 minutes, the plant working day and night, and the total time required to pass through the kiln is 12 hours, the kiln being a tunnel 76 yards long and 6 ft. 6 in. wide. In the first 37 yards of the travel the green briquettes are gradually dried and heated by the waste gases drawn from the firing zone through the kiln to the chimney, the maximum heat zone being in the next 16 yards. The final 23 yards is a gradually cooling zone, in which the incoming cold air is utilised. The kiln is fired in the hot portion by blast furnace gas, using hot air from the cooling off portion, the temperature in this hot zone being 2,280 to 2,370 deg. F. (1,250 to 1,300 deg. C.), with an oxidising atmosphere and a total time of operation of 2¼ hours out of the 12. The calcined briquettes are then conveyed direct to the blast furnace. It may be stated that almost any kind of available gas can be used for heating the kiln, and producer gas or coke oven gas is often utilised, whilst also even direct coal firing is another alternative, requiring about 1½ cwt. of coal per ton of briquettes.

* * *

The Use of High-Pressure Steam

There has been much talk for a number of years of utilising considerably higher steam pressures for power station work, but the actual progress made has been very slow. Much interest, therefore, is being attracted by the new power station in course of erection at Waukegan, Ill., near Chicago, in which the steam pressure is to be 400 lb. per square inch, being the first plant in the United States to exceed 350 lb. It may be remarked that there are three or four plants in America working at this latter pressure, one in Paris (Gennevilliers Power Station), whilst in England there are two plants, one at 425 lb. (North Tees), and one at 350 lb. (South Wales).

The boilers at the Waukegan Power Station are of the new "Babcock & Wilcox" design, something on the lines of the "Babcock" marine type of boiler on the inclined header principle, the tubes being in two sections, the upper section consisting of 17 groups of 2 in. tubes 15 ft. in length, and the lower section 8 groups of 3¼ in. tubes the same length, the superheater being placed between the two groups, and consisting of 3 rows of 2 in. tubes.

The boilers are of very large dimensions, each boiler having 14,086 square feet of heating surface, with 2,485 square feet superheater and 8,837 economiser surface, having a normal output of 100,000 to 120,000 lb. per hour, superheated to 700 deg. F. The combustion chamber is very high, 21 ft. 7 in., on the usual American practice, the grate area of the stoker being 383 square feet, and the ratio of the grate to the boiler heating surface 1 : 37.

Another new American high-pressure water-tube boiler is that of the Power Speciality Co., and Messrs. Thos. E. Murray, of which units are now working at 225 lb., but which, it is claimed, with very minor alterations, would operate at 1,000 lb. without difficulty. The installation consists of tubes of peculiar design, bent into hair-pin shape, between the headers, which are very small in diameter, whilst the heating surface is increased by means of gilled rings shrunk on the tubes, each gill being composed of five close-fitting rings. The installation is arranged with a very large steel tube economiser, so that the temperature of the exit gases leaving the boiler is very high, about 700 deg. F., the extra heat being absorbed in the economiser, which increases the rate of transmission in the boiler. There is, of course, no question, from a theoretical point of view, that these "super" steam pressures are an advantage, since once the latent heat of steam loss is got over, all the additional heat put into the steam is direct gain. The trouble is, however, as to what exactly is the resulting wear and tear on the plant, and it is on this point that it is always very difficult to get any definite information as regards existing high-pressure plants.

One of the results of this tendency to higher pressures seems to be the substitution of the cast-iron feed-water economiser by the steel tube economiser. This would appear to be a mistake, as cast iron is much more resistant to corrosion than steel, and the difficulty of the higher pressure could easily be got over by placing a turbine feed pump between the boiler and the economiser, so as to take the boiler pressure off the tubes. It certainly would seem, although definite information is also required on this point, that the trouble of the extra feed pump, together with the small extra space occupied by the cast-iron economiser, is much more than ample compensation for the corrosion, wear and tear, and breakdown of the steel tube economiser.

INDUSTRIES

Conducted by FRANK DAWSON.

THIS SECTION DEALS WITH THE GREAT BASIC INDUSTRIES OF INDIA. IN THE PRESENT ISSUE WE DEAL PARTICULARLY WITH MAGNESITE

The Modern Steam Laundry

The data for this article together with all the blocks used has been supplied by the courtesy of Messrs. Manlove, Alliott & Co. Ltd.

IN view of the fact that the steam laundry is almost an essential of daily life, it is surprising that so little is known, by the majority of those contributing to its support, of the various processes which obtain, and the machinery used in connection with the industry.

It is usually sufficient for the ordinary individual to complain, should his linen be badly laundered or his collars void of that high glossy finish which is so desirable, and the obtaining of which is the cause of more complaint owing to the excessive wear and tear necessitated.

The equipment of the modern steam laundry is such as to obtain by mechanical means the nearest possible approach to hand washing, whilst the wear and tear on the linen, assuming that the operators of the machines are experienced in their manipulation, is considerably less than obtained prior to its advent.

Following the routine of operations at a modern laundry, the work is first of all carefully examined and sorted, marked distinctively should such be necessary, and all white starched work, coloured goods, woollen apparel, etc., divided, so as to allow of each being separately dealt with.

The first operation is the washing, which operation also includes boiling, rinsing and blueing, all of which are dealt with by an all-metal washing machine of the type illustrated in Fig. 1.

The clothes are placed in an internal compartment constructed entirely of brass plates, perforated to allow of free access of soap and water, with each perforation recessed and the edges of the holes buttoned to preclude any possibility of the linen being trapped and torn in any way.

The outer casing of the machine is of steel, galvanized, to avoid risk of iron mould, and the driving gear is arranged with gear which automatically reverses the direction of the inner compartment every two or three revolutions, and thus prevents the clothing becoming entangled.

Contrary to the pre-conceived opinion of the ordinary individual, the washing is not done by beating and knocking about in soapy water, but by a gentle rubbing action of the clothes upon each other.

The amount of soap and water contained in the machine is sufficient to cover the clothes, and no more, and thus forms a " flux " which permits of easy movement of the goods being washed.

After washing, steam is turned on to bring the temperature to boiling point and maintain it at this temperature. After this operation is completed, the water is run off and the cage again filled with warm water, which forms the first rinse. A second rinse is given with cold water, to which blue is added, and

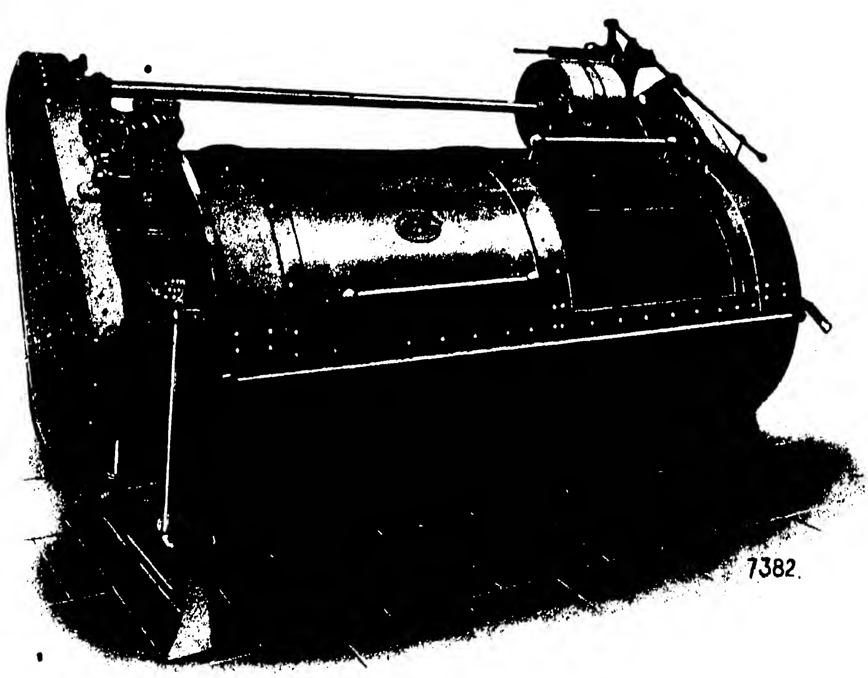


Fig. 1. Washing Machine

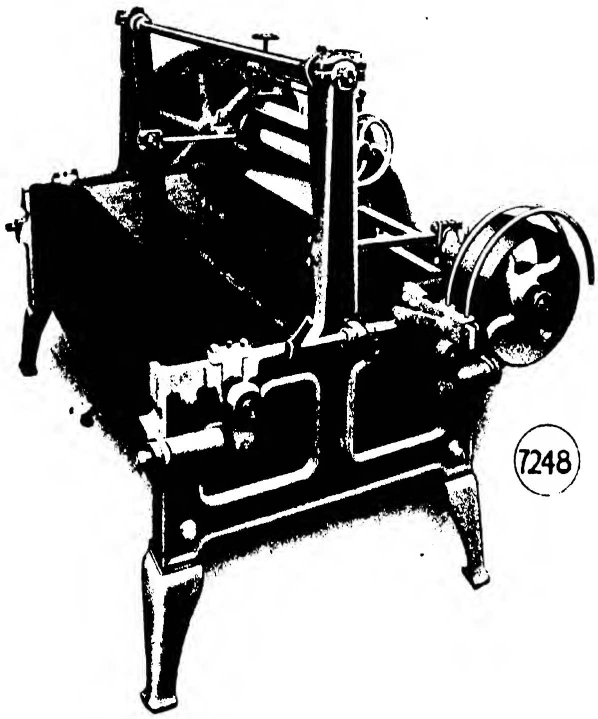


Fig. 2. Flannel Washer

this operation completes the washing process, unless table linen is being treated, in which case the linen is often starched in the machine before removal.

Flannels require very special treatment, to ensure softness, and to prevent shrinkage. For this purpose the temperature of the water has to be controlled so that it is high enough to take away the effects of perspiration, but not to destroy the softness of the texture. The machine illustrated in Fig. 2 is an excellent example of a type of machine which most closely resembles hand washing.

The centre piece is given a swinging motion by means of the crank and connecting rod, and the result is to squeeze the clothes first against one and then the other of the spring boards, which yield slightly to the pressure. The press is so constructed that it gives a slight upward rub to the clothes as they are squeezed. As the press recedes, the roll of clothes shaped by the press overhangs and topples over. The water quickly opens up the roll, and a fresh surface is constantly presented to the press and spring boards.

When the clothes have been thoroughly rinsed, the machine is stopped, the clothes taken out and placed into the hydro extractor (Fig. 3). This machine, when revolving at full speed, throws off all surplus water by means of centrifugal force through the perforations in the cage, the water being caught by the outside casing and conveyed to the nearest drain, whilst the linen is retained in the revolving cage. All flat work, when so treated, is dry enough to be transferred direct to the ironing machines for finishing. All other work, such as shirts, blouses, and other wearing apparel will be passed through the continuous drying room (Fig. 4).

This apparatus is fitted with a travelling band, on which the work is hung by means of clips at the feed side.

As each row of clips is filled, the operator gives the hand wheel at the side a turn until another row is available, the previous row passing into the heated chamber. As the goods pass through the machine, they are subjected to a continuous blast of warm, fresh air, which is changed several times a minute, the air current being set up by a blower sucking up cold air and forcing it through heated tubes into the drying room. Inside are two circulating fans which ensure the air passing on all sides of the work.

On arrival at the delivery side, the clips automatically release the work, and it is then ready for finishing by hand irons or steam-heated presses.

The flat work, such as table cloths, sheets, towels, is fed directly into the "Decoudun" ironing machine, where it is completely dried and finished with a high polish. (Fig. 5.)

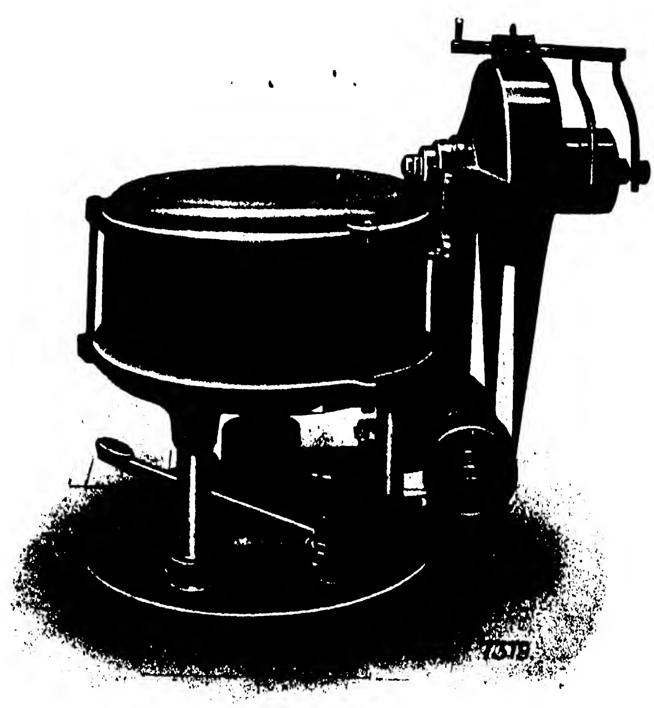


Fig 3. Hydro Extractor

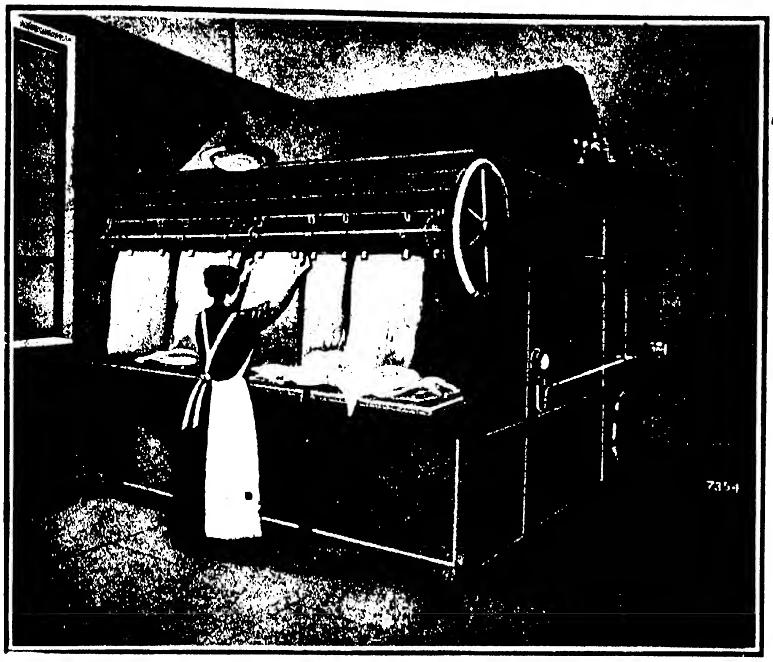


Fig. 4. Continuous Drying Room

These machines consist essentially of a heated roller, suitably clothed, working in a concave steam-heated bed. The work is taken round with the roller as it revolves between the padded service on the roller and the polished surface of the bed. The result is a highly glazed surface on the side adjacent to the bed. The material is at the same time completely dried, owing to its contact with the large heated area of the bed.

Collars, dress shirts, and cuffs, are, after washing, starched, and eventually finished in blocking machines as shown in Fig. 6.

The roller in these machines is usually heated by gas or electricity, in order to obtain the necessary high temperature for producing the gloss. The glaze is obtained by passing the work on the table, which has a reciprocating motion, repeatedly under the polished heated roller. A layer of felt packing is arranged on the table on which the work is placed, whilst the required pressure is reached by means of adjustable springs.

The collars, after being blocked, are usually (when a considerable number have to be dealt with) passed through a polishing machine, in which two padded rollers are arranged with one small hot roller between.

The collars, being fed between the upper padded roller and the central heated roll, are returned from the other side between the lower part of heated roller and the lower padded roller. The polish having been completed, the collars are passed through a seam dampening machine, and then moulded or shaped as required. The seams having been damped before folding, prevents cracking of the linen. After folding, the collars are passed through a heated porcelain tube into a receiving basket. The heated tube gives the final setting to the shape.

Body linen, flannels, etc., are usually finished on steam-heated presses.

The work is placed on a padded heated table and straightened out. The steam-heated polished head is then pulled down and locked for a few seconds, after which it is released, and the work moved round ready for further finishing. The gathered parts, or parts which cannot be dealt with on the table, are finished off by hand. The object of this machine is to obtain a more uniform finish than is possible by hand ironing, and, at the same time, increase the output.

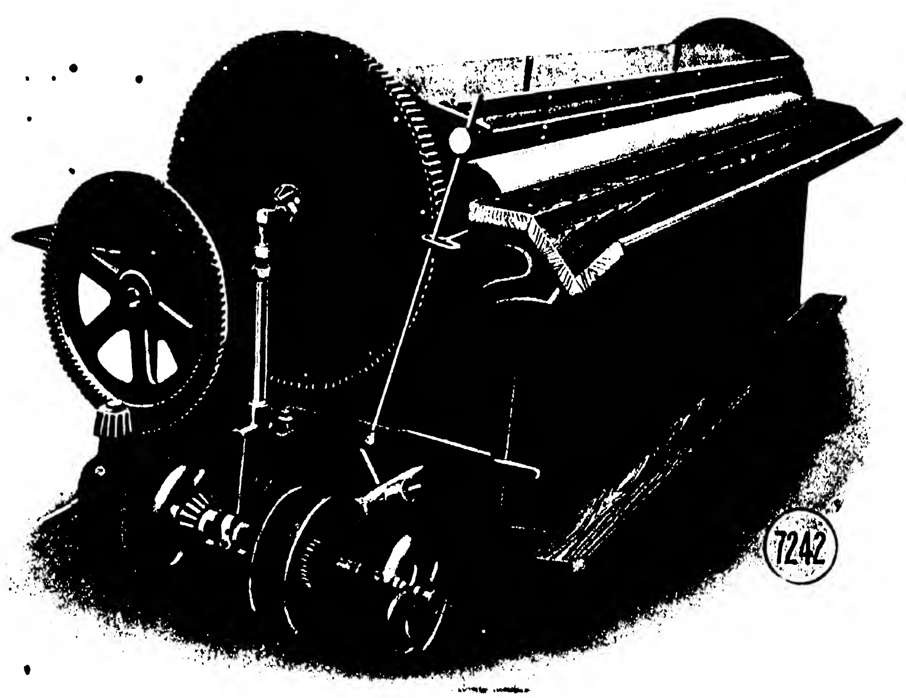


Fig. 5. Decoudun Ironing Machine

With the machines arranged in tandem, so that as one machine is locked the other is released, the operator is at work all the time, preparing work on one machine whilst the other is finishing. In this way one operator can do the work of about six hand ironers.

A steaming device is available for finishing flannels to ensure softness.

In addition to the apparatus described, there are various special machines, such as goffering rolls for frills, and marking machines for collars, etc., which are advantageous to use where there is sufficient turnover to warrant the cost.

For the successful running of the laundry, extreme care must be exercised in marking, sorting and packing departments, owing to the great annoyance to owners when the work is returned incomplete.

Everythihg, as received, must be checked with the list sent in, and marked for identification so that it is returned to the sender.

After marking, the goods are sorted in various bins, so that similar goods are washed together, as the treatment naturally has to be varied according to the material of which the goods are made.

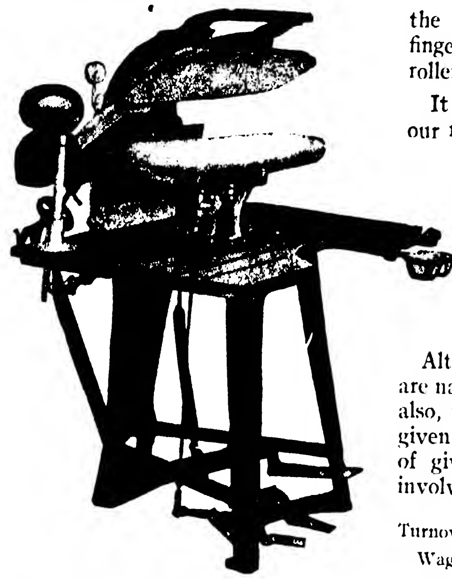


Fig. 6. Blocking Machine

For safety in working, all gears, etc., are guarded, wherever possible, whilst such machines as "Decoudun" ironing machines are fitted with auto-safety guard, which immediately stops the machine should the operator's fingers get too near to the revolving roller.

It will doubtless be of interest to our readers to have some idea of the relative costs of running a modern laundry, together with present-day prices of new plant; the following approximate figures, taken from a successful laundry in England, are therefore given.

Although the running costs in India are naturally very different, and vary, also, in different districts, the figures given will be useful for the purpose of giving some idea of the capital involved.

Turnover (per week)	£250
Wages, Salaries	125
Materials, Soaps, etc.	25
Rates, Depreciation, Rent, etc.	80
Profit	20

Average value, 90 pieces to £1.

Such a plant would cost £3,500, with engine and boiler. Building, extra.

The Eastern Oil Fields (ii)

By SIDNEY H. NORTH, Assoc. Inst. P.T.

(*Continued from page* 238)

IN Hindu-Kush the formation is practically the same. It may be instructive to those interested in this aspect of the subject, to reproduce a table appearing in "The Petroleum Year Book," 1922, illustrating the similarity of formation in the most productive fields of the Far East.

INDIA—
- N.W. Provinces;
- Suliman Range—Dark shales overlaid with cretaceous sandstones.
- Takhaat in Suliman—Sandstone overlaid by limestone of cretaceous system.

PERSIA—
- Shales overlaid by coarse sandstones and grits.

BAKU—
- Productive strata.
- Shaly marls and fine-grained calcareous sandstones.

PUNJAUB—
- Striking similarity to Baku strata.

BURMA—
- Soft sandstones and shales of middle or lower territory.

JAVA—
- Middle Miocene; Few limestones, characterised by light coloured shales and sandstones with conglomerates.

The nature of the oil obtainable from Sherani has a specific gravity of .81 (at 15.5 deg. C.), and a flash point of 84.29 deg. F. It is remarkable that the specific gravities of several fractions obtained during the fractional distillation of Sherani oil are very similar to those of Russian kerosenes. The Suliman oil has a specific gravity at 60 deg. F. of .83, the flash point being 128 deg. F. (Abel test).

Another promising part of India lies in the extreme south-west, in Travancore and Cochin. According to Mr. H. W. Perry, of Trichinopoli, complete combinations of all the necessary conditions for the formation and preservation of petroleum exist in two large deltaic, estuarine, and littoral areas on the west coast of Southern India. These are, firstly, the delta of the Periyar, Ermakulam, and adjacent rivers draining into the large lagoons east and north-east of Cochin; and, secondly, the delta of the Mavalikaray and other rivers draining into the Vembanad Lake, east and south-east of the port of Aleppy, in Travancore.

In both these areas there are the same "Lagoons, mangrove swamps,

and territorial deposits separated by strips of littoral sands from truly marine silts and clays," as are found in Trinidad, California, the Gulf States of America, Borneo, Peru, and other oil-producing places at the present time, and as existed at Baku and in Burma and Mexico, during Tertiary times.

There are, in addition, several much stronger and more direct evidences of the presence of petroleum in these localities. The first of these is the evolution of methane, or oil-gas, from the upper and less perfectly scaled horizons that are characterised by the presence of lignite. The fishermen living and working on the coast near the Aleppey and Cochin mudbanks will readily point out to any visitor several places both under tanks and pools inshore, as well as along the beach and from one to two miles out in the sea, where bubbles of gas of various sizes may be frequently seen rising up through the waters. At times, when there is a surf and the waves recede from the shore and relieve the pressure on it, fairly large bubbles may be observed bursting up through the wet sand at the base of the retreating rollers; and out at sea, whenever the hydraulic pressure on the margin of the delta here becomes variable through the disturbance caused by the monsoons, the gas bubbles escape more frequently, and generally over large areas.

Indian Deposits

The existence, therefore, of petroleum-bearing beds under both the Cochin and the Aleppey deltaic areas can scarcely be questioned, for all the conditions necessary for the formation and preservation of this oil in them are markedly present, and they also have long and repeatedly exhibited all the phenomena indicating the presence of gas under pressure, and of petroleum itself, that are regularly observed in the vicinity of other proved oilfields all over the world.

It is estimated that an area of over 100 square miles in these parts of India is characterised by indications of extensive oil deposits.

Baluchistan is at present an unknown land, as far as oil is concerned, although several British companies, among which is the Burma Oil Company, have taken up concessions in certain districts. A few test wells have been put down, but without any very favourable results. It is not improbable, however, that with a more systematic exploitation, petroleum deposits of commercial value may be discovered.

Persia

We now come to that country which, I believe, is destined to rank as one of the most prolific oilfields of the world. Its geographical position is most advantageous from several points of view, one of the chief being that it is the gateway to those Far Eastern countries whose markets are so prospectively immense as to afford an outlet for unlimited supplies. At the present time, when we speak of the Persian oilfield, we think of only that portion of the country which lies on its southern boundaries, and near the shores of the Persian Gulf. The reason for this is that this is the only portion which has been opened up, and the great value of which is proved. The petroleum region of Northern Persia is comparatively little known, though geologists testify to its importance.

The Southern field traverses several large districts, the Maidan-i-Naftun zone, the Bakhtiari zone, and the Ahwaz-Pusht-i-Kuh. Writing of the first named in *Oil Engineering and Finance*, Mr. George Howell remarks that the Fars series is partly built up of beds of detrital limestone, mainly a derivative of the Asmari series, and in this region wells all flow under strong pressure, and are very long-lived. There is one well, known as the No. F7, from which the Anglo-Persian Oil Company has been getting its main production for some ten to twelve years past. The total production from this well during ten years has been 4,000,000 tons (26,000,000 barrels); it is now giving at the rate of 2,000 tons (13,000 barrels) per day; the present is an increase on average total flow. In speaking of this well, it is an admitted fact that no other well of equal producing capacity and continuity has ever been known in any field producing the same class of light oil; and it is also an admitted belief that the Anglo-Persian Company will, when the transport facilities become commensurate with larger production, be able to bring in many similar wells as the No. F7. The Maidan-i-Naftun zone is a potential field of very great promise, and wells drilled in this region, as those producing, will be natural "flowing" wells of great daily volume, and that with this high-producing capacity, the cost of producing the oil will be correspondingly low.

The structure of the Maidan-i-Naftun, however, was much less disturbed, and presents a very much easier problem for the drill; and the depositions of the Fars series, which contain the recognised oil horizons, is conformable and undisturbed by contemporaneous earth movements; not so with the depositions of the Bakhtiari series, which are the superimposed beds of the Fars. There is one happy conclusion to make after studying the geological data of the Bakhtiari country as a whole, and that is that the strata contain prolific wealth in rich stores of oil.

Mesopotamia

The Ahwaz and Mishdakh areas (the latter fold runs to the west of Ahwaz and in a N.N.W. direction) have well-developed structures indicating high oil potentialities; these can be paralleled in oil values with the present producing zone of the Anglo-Persian Oil Company's activities, and it may safely be estimated that these lands of Mesopotamian influence (geographical sense) will not disappoint the drill, and at moderate depths; no deep drilling need, as indications go, be resorted to. The oil reservoirs may be found buried, unexposed, in the extended flanks of the respective mountain ranges which border Western Persia (called by the natives Western Iran), and the parallel limestones of the Zagros mountains.

It is evident from geological data that the district lies well within the oil-belt, and forms the eastern section of a much-sought-after Mesopotamian oil zone. That there is abundant concrete evidence of the existence of oil, and that the rock-structure, although unconformable in a few places, is most highly developed, and forms ideal reservoir rocks for large oil accumulation, is now beyond question. The future of this westerly field will be watched with the greatest interest.

A brief reference to these two further regions is necessary to complete a somewhat sketchy review of Persia as an oil-containing country, although at the moment the data on hand are not very voluminous, and the formations have as many similarities as dissimilarities; a repetition, therefore, of the rock structures would possibly be tortuous. Briefly, the island of Quishm is the largest island in the Persian Gulf—60 miles long and 8 to 10 miles in width. The Upper Far beds, clays, marls, sandstones, and shelly limestones pre-

dominate, the strata being divided into the Upper Arenaceous and Lower Argillaceous groups. There are several dome-like structures, evidently produced by two sets of gentle earth movements, S.S.E. to N.N.W. and S.W. to N.E. respectively. The Persian mainland also offers phenomena of great geological interest to those searching for virgin oilfields. Many seepages have been located over the districts examined, but before the ground has been "thro" tested, it is not wise to pronounce the verdict; it is only the future that will be able to do that. These considerations, nevertheless, are only the fringes of a powerful oil undertaking, a company which, in its activities, has grown from the strenuous child into a powerful British oil undertaking.

Little can be said in regard to Mesopotamia, except that surface and geological investigations indicate it as possessing those features which are common to extensive oil deposits. In his recently published great work on the petroleum industry, Dr. David T. Day, late chief of the U.S. Geological Survey, states that a great oil region is being developed in Mesopotamia, extending from Hit, on the Euphrates, to El Deir, a distance of 200 miles, north-east to Herboul, near Zakhu, and east into Persia. The fields of Mesopotamia lie in the valleys of the Lower Euphrates, Tigris, and Karun rivers, north of latitude 30 deg. in the Vilayets of Mosul, Bagdad, and Basra, and extending north as far as Harbel in the Caza of Sakho, 60 miles north of Mosul, where Eocene outcrops exist. The fields have a general north-west south-east trend, paralleling Tertiary fields, which lie farther east, the oil being found where the mountain ranges terminate near the ocean. In their geology the fields are anticlinal and domal. The surface indications consist of seepages of oil, salt and hydrogen sulphide from Miocene saline gypsiferous marls, limestones and sandstones, and there are additional oil-bearing strata of cretaceous age. The formations mentioned are generally accepted as indicative of prolific oil deposits, and are similar to those existing in Southern Persia.

It is pretty evident, therefore, that those who secure a predominant position in the oilfields of Persia and Mesopotamia will be well on the road to controlling the Far Eastern oil trade, and, to a not unimportant extent, that of Europe.

Some New Forms of Kilns

(*Continued from page 313*)

divide the tunnel up into a number of chambers, short flues in the side walls being provided to carry the gases from one chamber to another. In order to ensure the material heating throughout its height when piled on the truck, the openings for the passage of the gases are only made in the lower portion of the flue walls, thus ensuring the heating gases flowing across the lower parts of the material as well as around the upper parts. Combustion takes place about the centre of the kiln, the heating gases following a zig-zag path to the end that the material enters. The cooling air is let into the exit end of the kiln, following a zig-zag path and becoming more highly heated until it reaches the point of combustion.

Arrangements are made by which an excess of air may be admitted in order to ensure proper cooling, and the excess drawn off before the combustion point is reached. The trucks carrying the material in the design shown are 5 ft. long by 10 ft. wide, and are travelled 5 ft. at a time. Arrangements are made to prevent by-passing around the ends of the division walls on the truck and over the top.

It will be seen that this design greatly reduces the length of the kiln, provides for even heating over the cross sectional area of the tunnel, and removes any difficulty in cooling the material. The trucks are sand-sealed about at the bottom, and a ventilated pit is provided through the length of the kiln beneath the truck bottoms, so that ready attention can be given to any mechanical part.

A problem which was recently put up to us was the proper burning of large glazed goods in a muffle. The material was to be slowly and evenly burned at a temperature of about 1,100 deg. C., and slowly and evenly cooled. For this purpose we designed an annular circular tunnel kiln, with the heating gases muffled. The continuity of the tunnel is broken at the unloading and loading point, but the annular firebrick tray carrying the material is continuous and unbroken. The heating of the kiln is by means of producer gas burned in six horizontal flues arranged one above the other in the side walls of the tunnel. These flues being separated throughout their length, the intensity of heat to the various parts of the kiln is controllable, and an even temperature preserved through the height of material. The tray is moved by electric motor and gearing 10 ft. at a time, the operation taking some 30 seconds.

The combustion zone is approximately opposite the unloading zone, and the heating gases flow toward the inlet end for the material. Mechanical draught is applied by means of a fan and motor. Cooling is controlled by the admission of air into the muffled flues about the outgoing material, and a regulated supply of air is admitted inside the muffle at the exit end to ensure the final cooling. Special arrangements are also made for warming and removing the moisture from the unburned materials as they enter the kiln. The chief advantages of this kiln are convenience of working, elimination of trucks, even heating and economy of fuel. One of these kilns will be working early next year, but the principle has been proved on a kiln of similar design forming part of a chemical process.

In designing these kilns we have tried, first of all, to grasp the fundamental needs of the manufacturer. These, of course, vary very greatly, but once these needs are fully understood, the work of design is not so difficult a matter.

Palm Oil and its Prospects

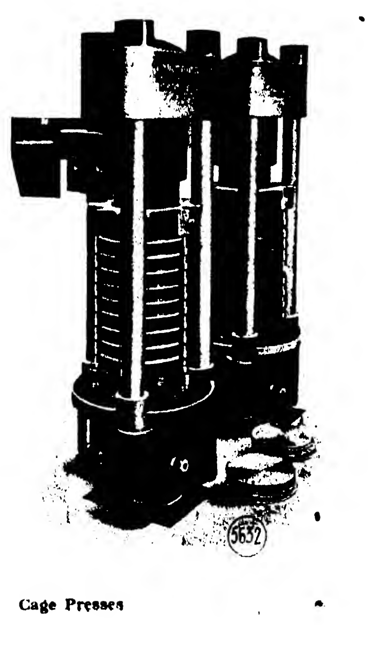
We are indebted to Messrs. Manlove, Alliott & Co. Ltd., for the loan of all blocks used in this article, which illustrate this firm's hand operated plants

CONSIDERABLE interest has been aroused within recent months as regards palm oil. The scientific planting of the palm is said to give the same advantages over the wild palm in its African home, as our planted rubber has over the wild rubber in Brazil. Now that the outlook for rubber is by no means cheery, it would be a paying proposition for the enterprising Indian agriculturist to open up a few hundred acres with the African oil palm. The amount of hand labour required is very much less than with rubber, and with the improved modern methods of machine cultivation the industry is bound to prosper. Serious risks have undoubtedly to be faced in attempting to establish a new crop; hence it is always advisable for the cultivator to obtain all available information before he invests his capital. This article contains a few hints to intending cultivators, and it also touches on the prices, profits and prospects in connection with the industry. This information should, however, be supplemented by drawing upon the experience of other countries. The fact that all tropical planters are well posted up with a knowledge of agricultural conditions in the Tropics will fairly diminish the risk of undertaking the plantation of a new crop. Nevertheless, there is always a certain degree of uncertainty which should warrant caution. The vast bulk of palms in Africa were planted haphazard, and received very little attention. That systematic cultivation increases the oil capacity of the fruit is exemplified by the Malayan-planted palm, which produces a thicker pericarp and also an increased proportion of oil than the African fruit. The following are some very interesting facts about the average returns of the oil palm, which will also be invaluable data to prospective planters. A mature bunch of fruits weighs about 40 lb. to 50 lb. The fruit alone weighs 30 lb. Taking 100 lb. of fruit as a basis, the pericarp or outer covering of the nut from which the oil is extracted weighs about one-third of the weight of the fruit, and contains about 50% of easily extractable oil, *i.e.*, about 16% of the weight of the fruit, which will be 32 lb. The stone is two-thirds the weight of the fruit, which will be about 68 lb. The kernel—from which a higher class of oil is made—is one-third the weight of the stone, *i.e.*, 20% to 24% of the weight of the fruit, the weight of which will be 24 lb. Forty per cent. of kernel oil is extractable from the kernel, whilst 7% is left in the cake. This may be extracted chemically afterwards. The weight of the oil will be 9 lb. About 60% of the kernel remains in the form of a hard cake; this will be 15% of the weight of the fruit. The average yield from 100 lb. of fresh fruit may be worked out on the above data as follows:—

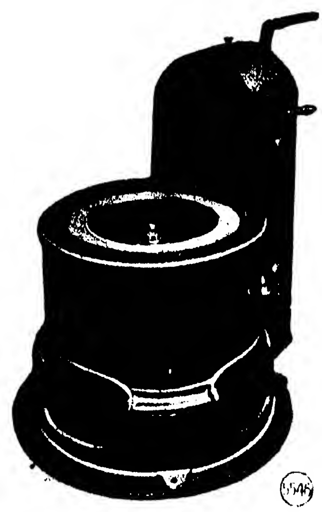
Palm oil	16%
Kernel oil	9%
Kernel cake	15%

A healthy tree bears 150 lb. of fruit per year, hence the yield from each tree will be as follows:—

Palm oil	25 lb.
Kernel oil	14 lb.
Kernel cake	22 lb.



Cage Presses



Centrifugal Extractor

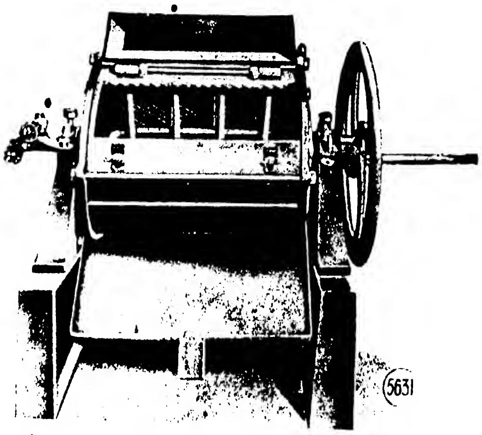
An acre usually contains 48 trees, planted at a distance of 30 ft. by 40 ft., and the yield is:—

Palm oil	1,075 lb.
Kernel oil	572 lb.
Kernel cake	903 lb.

Curing and Cultivation

The process of manufacture is simple. The first step is known as "husking" The fruit is pulled out of the bunch at collecting stations, to avoid carting a mass of useless stuff to a distant factory. Then the fruit is boiled or steam-heated to soften the fibres, and afterwards passed through a depulping machine by gravitation, which strips the pulp from the stones. The latter are then crushed in a special machine, and the kernels extracted, the kernel oil pressed out, and the oil and cake shipped separately. The pulp is then reheated, and put into a powerful press. The extracted oil is then treated again, and refined for shipment. If good returns are desired, it is essential that the machinery which is used should be in good order. The dross from the pulp, the shell of the stones, and the mass of the

bunch, are usually burnt, and the ash returned to the soil. This replaces in a soluble form whatever little mineral plant food may be taken from the soil, and thus increases the fertility of the palms. The actual products, barring the cake, are almost entirely organic, so that long cultivation will not impoverish the soil. As regards cultivation, the plant requires plenty of water. Its root system acts on similar principles to that of the coconut tree, hence it requires larger quantities of easily available plant food. To render this possible, the soil should always be kept in a moist condition and open, so as to prevent loss of moisture by capillarity, and to obtain the more rapid nitrification of the soil required by the tree. The ground must be clear of all timber. The plants should not be put out until they are nearly twelve months old. Hence a cultivator has over a year to prepare the ground, get a good burn, haul off the valuable logs with tractors, and "stump" the whole area. The logs, which are always commercially remunerative, will go some way towards paying for the expenses of preparing the land. After the land has been "prepared," ploughing is resorted to. Catch crops are usually grown for several years. The distance of the plants being 30 ft. apart, gives ample space for this. Ploughing tends to impart a free tilth to the land, thus enabling the rootlets to run out and spread, instead of having to fight their way into the hard, unyielding soil. This serves as an immense impetus to growth, which is never lost as long as the soil is cultivated. Catch crops are profitable in their own way, especially in providing a shelter from prolonged exposure. If they are ploughed in, they are invaluable as a green manure in building up humus and plant food in the soil. This may mean a few pounds of extra capital; it will, however, be repaid many times over by the results obtained.



Depericarping Machine

Remunerative Returns

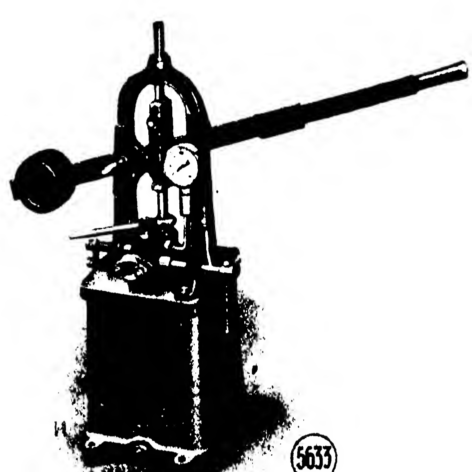
Taking an acreage of 1,000 acres as a basis, the returns from such an estate may be worked out as follows: 1,000 acres is estimated to yield 700 bunches per day, averaging 50 lb. each. This will be equal to 21,000 bunches per month, weighing 1,050,000 lb., or 450 tons per month, or 5,400 tons per year. Yielding 2,300 lb. of fruit per day, or 3,700 tons of fruit per year. This crop should give a return of palm oil at 24% of weight of fruit, *i.e.*, 888 tons; kernel oil at 8% of fruit, *i.e.*, 296 tons; kernel cake at 12% of fruit, *i.e.*, 444 tons. The value of these returns will be as follows:—

	£
888 tons palm oil at £40 per ton ...	35,500
296 tons kernel oil at £50 per ton ...	14,800
444 tons kernel cake at £8 per ton ...	3,550
Total return	£53,850

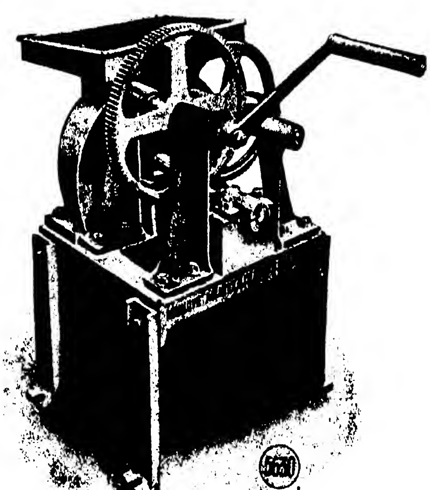
The estimated cost of production is as follows:—

	Rs.
Field work, including transport to factory and machine cultivation	80
General, staff, local agency, and sundries	45
Factory work, including casks	115
Total per year ...	Rs. 240

The cost does not include insurance, freight and duty, which must be allowed for separately, as those are quantities which fluctuate and vary, and depend upon ruling values at the time of sale. We may, however, fix the total cost of production at £30 per acre, or £30,000 per 1,000 acres. Hence the nett balance of profit will be £23,850. So far as present conditions indicate, there does not seem to be much likelihood of the supply of animal fats from either cattle, sheep or pigs becoming sufficiently abundant for the price to fall seriously, and affect that of palm-kernel oil. As far as fats are concerned, the indications are all the other way. The consumption of fats is steadily and largely increasing, while the world supplies of live stock are likely to fall below, rather than to exceed,



Hydraulic Pump



Nut Cracking Machine

the demand. There certainly is a distinct possibility of producing palm oil improved in quality as to be edible. Effective competition may also set in between palm oil and coconut oil, both these oils being similar in composition and properties, and for practicable purposes interchangeable. The production of both the oils is increasing steadily, and if the cost of one or the other is suddenly reduced to a quite different level, it is likely to affect the general position. There is plenty of scope in India for oil-palm plantations. It is not at all a difficult matter, for instance, to obtain lands near rivers, and with the facilities of labour and modern machinery, there are the greatest hopes of prosperity for the Indian agriculturist. The future of palm kernel oil appears sufficiently secure to warrant every reasonable effort to establish the trade in palm kernels in India.

The Magnesite Industry in India

By EDGAR C. EVANS, B.Sc., F.I.C., M.I.M.E.

IF we review the industrial history of India during the depressing twelve months through which we have passed, it is becoming more and more clearly evident that the industrial future of the country is going to depend primarily upon the development and exploitation of the great national resources in which India is so rich, and only in a secondary manner, in the growth of those highly specialised industries in which Western countries, with their surplus of highly skilled labour, are able to excel.

India is exceedingly rich in natural products which are becoming more and more valuable as time goes on, and perhaps one of the most important of these is magnesite. In the great Salem deposits in the Madras presidency, India possesses a wealth of raw material which is of continually increasing importance. The growth of the basic process in the iron and steel industry is developing a market for magnesite bricks which is rapidly growing in volume. A very big demand has existed in Germany for many years, and this is rapidly extending in other countries. France, Spain, and South America are now big buyers, and even England, the home of acid steel, is now rapidly taking up the basic process, and most of the new steel furnaces which have been erected during the past few years have been equipped with basic hearths.

The possibilities of magnesite can be realised from the fact that an open hearth furnace requires from 30,000 to 80,000 magnesite bricks, according to its size. They are also used in convertors, mixers, electric furnaces, etc., so that there is always a steady demand which is rapidly increasing in dimensions and importance.

Up to the present, however, the valuable Indian deposits of magnesite have only been worked to a slight extent. In normal years about 15,000 to 16,000 tons per annum only are produced, and of this only about 6,000 tons are exported. The bulk of this went before the War to Germany and Belgium, chiefly as calsised magnesite, while the United Kingdom absorbed only a very small proportion.

The limited character of the development of this industry can be realised from the fact that the Grecian mines alone, from which the United Kingdom draws its main supply, produce over 100,000 tons a year, whilst the Styrian mines produce normally considerably more. It is a matter for surprise that under these circumstances the industry in India has not attained more flourishing dimensions.

Uses of Magnesite

Magnesite is a material which has a number of uses other than those of the iron and steel industry. It is used for making magnesia cements, for dust-proof flooring; it is used as a plaster in fire-proof partitions; as an ingredient of steam packing materials, where its insulating character makes it of considerable value, and in the manufacture of millstones and polishing wheels.

Its principal use, however, is in the iron and steel industry, as a refractory material.

Magnesite Bricks

The manufacture of magnesite bricks has already been commenced in India. A small quantity is being made at Kumardhubi, chiefly in connection with the domestic requirements of the Tata Iron & Steel Company, but the production represents only a very small fraction of the potential demand that exists.

It might perhaps be of interest to analyse the possibilities of establishing a large scale magnesite industry in India.

At the risk of wearying the technical reader with facts that are—to him—of an elementary character, it might not be amiss to outline some of the causes which make magnesite such an important refractory material.

Chemically speaking, magnesite is closely allied to limestone. While limestone is a carbonate of lime, having a composition represented by the formula $C_a CO_3$, magnesite is a carbonate of magnesia $M_g CO_3$. The chemical properties of both are very similar. Limestone and magnesite, if heated to 800 deg. C. to 1,000 deg. C. give off carbon dioxide and leave behind lime and magnesia respectively. Both of these are white solids, which are highly infusible; both can be readily slaked, and both are basic in character and dissolve readily in acids.

Magnesite possesses a property which is of considerable importance. If, instead of burning it at a tem-

perature of 800 deg. C., the temperature is raised to 1,400 deg. C. to 1,700 deg. C. (depending on the character of the magnesite), it loses its capacity for being slaked. Water has no action upon magnesite which has been burnt at this high temperature. At the same time, a remarkable change in the properties of the burnt magnesite takes place. It becomes much denser, it gradually vitrifies, and becomes converted into a very hard igneous-like material which is known as dead burned magnesite. This is the variety which is of the greatest use in the iron and steel industry, and it is from this material that magnesite bricks are made. Its value as a refractory lies in the fact that on prolonged heating at the temperatures and under the conditions under which magnesite bricks are used, no further shrinkage or change in density occurs.

The dead burned variety is therefore much more valuable, and commands a much higher price, than the magnesite which has been heated to a lower temperature.

Very little dead burned magnesite, however, is made in India, and the bulk of the material mined is sold either as raw magnesite or is heated only to about 800 deg. C. and sold as caustic magnesite.

At first sight it may seem remarkable that no attempt has been made to produce dead burned magnesite on a large scale, but there are several reasons for this. The principal question is one of fuel. The production of the dead burned variety requires a very high temperature, and this is not easy to maintain with Indian coal if used in the raw state, owing to its very low quality.

The coal consumption also is very high, and as the cost of fuel in the neighbourhood of the magnesite deposits is by no means low, this makes fuel a very expensive item.

A brief consideration of the subject, however, will show that these difficulties are not so serious as they may appear at first sight.

Ample supplies of coal are available in the Hyderabad mines of the Mysore State, and it should be possible to deliver the coal at the magnesite mines at a price which should allow of a return on the expenditure involved.

Alternatively, the magnesite could be transported to the coal mines on the lines of iron and steel practice, so that the ore moves to the fuel, and not the fuel to the ore.

The actual cost of the fuel should certainly not prove to be a bar to the establishment of a magnesite industry in India.

Temperature for Burning

The next question is whether the fuel itself is good enough to allow of the temperatures necessary to produce dead burned magnesite being attained. Hyderabad (Deccan) coal is not *per se* an ideal material for the production of high temperatures. Compared with British coal, its calorific value is low, it has a high ash content, and a high percentage of water. On the other hand, it is a coal which readily lends itself to the production of producer gas, and gas-fired kilns are ideal for the manufacture either of dead burned magnesite or of magnesite bricks. There are then no technical difficulties in the way. The main question is one of fuel consumption. Under British conditions it is generally estimated that 15 cwt. of fuel are required to produce 1 cwt. of sintered magnesite; 5 tons of sintered magnesite are required to make 1,000 bricks, and if these are burnt separate from the raw magnesite, a further 25 cwt. of fuel is required. The total coal consumption per 1,000 bricks, therefore, under British conditions would be as high as 5 tons.

If British practice were followed in India, this figure would be considerably exceeded, owing to the low heating value and to the necessity for converting it into producer gas. It is therefore important that every possible means should be adopted in India of reducing the fuel consumption. It is important, then, that the type of kiln chosen for use in India should be one giving the highest possible efficiency. Further, the temperature used should be as low as possible compatible with the production of the highest quality of burnt magnesite and of magnesite bricks.

The method of attaining these two apparently incompatible requirements opens up some very interesting problems. It has been assumed in the past by British experts that in order to secure the well-burned magnesite bricks, a temperature of 1,700 to 1,750 deg. C. is necessary. British makers have found by painful experience that bricks made at a low temperature—say 1,400 deg. C. to 1,450 deg. C.—crumble very badly in steel furnaces, and for that reason every possible effort is made to secure as high a kiln temperature as possible.

Even then, however, British-made magnesite bricks do not as a rule compare favourably with Austrian bricks. Austrian bricks are generally dense and crystalline in structure, whilst British bricks are more porous and amorphous.

Still, on analysis it is found that British bricks are generally purer than Austrian bricks, and contain a lower proportion of impurities, and, in the past, in view of this fact, it has generally been considered that the superiority of Austrian bricks is due to the fact that they have been burned at a higher temperature. The tendency in British practice, therefore, has been to retain this purity of composition, and, at the same time, to burn the bricks at as high a temperature as can possibly be attained.

It is comparatively an easy task to attain a temperature of 1,400 to 1,500 deg. C., but a temperature of 1,700 deg. C. upwards is very difficult to attain, and to maintain, in a brick kiln. Such a temperature would also mean that the consumption of fuel would be very heavy—wear and tear, repair and maintenance charges would be increased, and the costs of production considerably increased.

For that reason it is important that as low a temperature as is possible should be used, bearing in mind that the product must be completely burnt so that no further change of density occurs when it is used in the steel furnace.

Unfortunately, Indian magnesite suffers from the disadvantage that its vitrifying temperature is a very high one, and to secure that it be absolutely "dead burned" an extreme temperature is necessary. Fortunately, however, recent work has shown that it is a very easy and simple matter to overcome this difficulty.

Essentially speaking, Indian magnesite suffers from the fact that it is too pure. It seems rather a paradox to talk of purity as a disadvantage, but in many cases the presence of a small percentage of impurities is actually of considerable importance in determining the industrial value of a new material.

(To be continued.)

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

Manufacture of Handles from Indian Woods

By S. KAMESAM

Senior Assistant, Timber Testing Section, Forest Research Institute, Dehra Dun

FROM time immemorial, wood has occupied a prominent position as regards its suitability for handles. Every year, India imports lakhs of wooden handles from foreign countries — especially the U.S.A., from which country the chief imports are hickory, ash and beech. In India, we have some species of wood which can compete successfully with even the best of the imported woods as regards strength or beauty, or both. Up to the present, these Indian woods have not come into the limelight of public attention, not because of any intrinsic defect in them, but because no accurate data as regards their mechanical properties were available. The recently-started Timber Testing Laboratory at the Forest Research Institute, Dehra Dun, is doing pioneer work in this respect. The importance of work in this line cannot be over-estimated, as not only is India in a position to forego imports of handles from foreign countries, but with its large stands of *Heritiera minor* (Sundri), *Anogeissus latifolia* (Dhaura or bakli), *Olea ferruginea* (Khwan), *Schleichera trijuga* (Kosum), *Grewia tiliaefolia* (Dhamin), is certainly able to satisfy the most exacting specifications of handles for different purposes in foreign countries.

If handles of moderate weight and strength are wanted, woods may be had like *Cedrela toona* (Toon), *Pinus longifolia* (Chir pine), *Dalbergia Sissoo* (Shisham), *Morus alba* (Mulberry), etc.

If strength is a prime consideration, strong woods are available, such as *Heritiera minor* (Sundri), *Terminalia tomentosa* (Asna or Saj), *Olea ferruginea* (Khwan), *Dalbergia Sissoo* (Sissu), *Anogeissus latifolia* (Dhaura), *Ougenia dalbergioides* (Tinsa), *Grewia tiliæfolia* (Dhamin), etc. Though *Gordia Myxa* (Lasora) appears to correspond, with its low specific gravity and high elasticity and toughness, to American ash, it is not very durable. Sometimes, weight is essential, though this is the case with small, rather than large tools, and Petwun or Trincomali wood (*Berrya Ammonilla*), *Dalbergia latifolia*, *Mesua ferrea* suit this purpose very well.

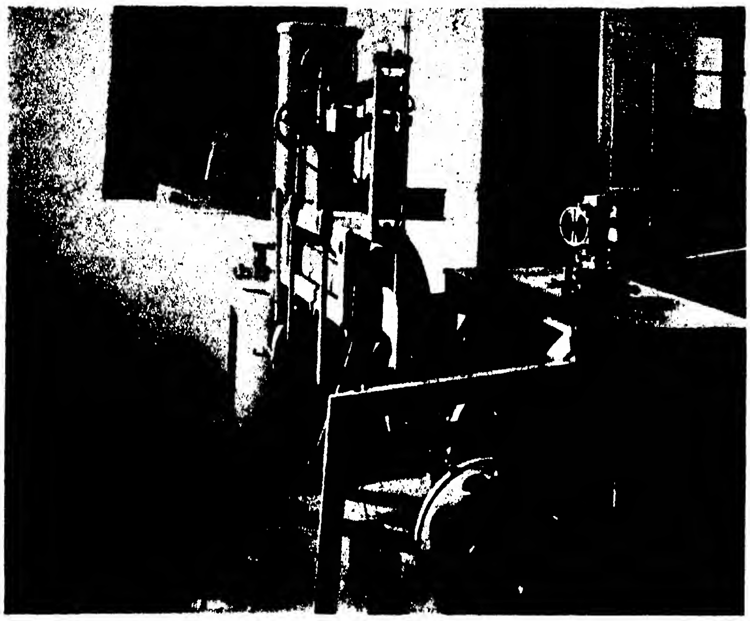
Elasticity is a prime requisite at times, combined with toughness, as in the case of axe handles, hammer handles, etc., which are roughly, long spindles. The eye of the Indian axe is usually circular, and the male bamboo, *Dendrocalamus strictus*, *Heritiera minor*, *Olea ferruginea*, *Dalbergia Sissoo* and *Grewia tiliæfolia* may be used, and these are plentifully distributed in the Indian forests.

Qualities of Woods

Sometimes, in using a handle the hand must slip to and fro, as with an axe chopping fire-wood or felling a tree, and a wood is required that will polish smooth, so that the hand will not be chafed. Many woods polish smooth, but there are very few woods to beat Trincomali wood in this respect. Beauty is sometimes, though not usually, considered in the selection of a handle wood, and the prejudice which formerly existed in America against the heart-wood of hickory was because it was red, and not white. Recently, the U.S. Forest Products laboratory has shown by numerous tests that white and red hickory of average growth are equally good.

The handles of pocket knives, table knives, and other cutlery, screw-drivers, etc., and in fact of a thousand articles of daily use, afford a considerable use for handsome and moderately hard woods. Our forests possess many of fine colour and close grain, among them being *Acacia arabica* (Babul), used in axes, chisels, gimlets, etc.; *Dalbergia latifolia*, used for the same purposes as the former, and also for Nepalese "Kukris"; *Lagerstromia tomentosa* (Leza), used for spear-handles; *Acacia catechu* (Khair), *Ailanthus excelsa* (Mharukh), used for sword handles; *Adina cordifolia* (Haldu) and *Artocarpus integrifolia* (Kanju), for handles of things which are not called on to endure sudden strains, but more for ornament or insulation from heat and electricity; *Chloroxylom swietenia* (Satin wood), for handles of axes, hoes, etc.; *Diospyros Ebenum* (Ebony, Tendu), *Mangifera indica* (Am), *Tectona grandis* (Teak), for a thousand miscellaneous articles of daily use where great elasticity is not required.

Woods are tested in the timber testing laboratory to determine their fibre stress at elastic limit, modulus of rupture, modulus of elasticity and work up to elastic limit in static bending, which give an insight into their properties of flexure under a gradually increasing load, causing a slow, but uniform, strain on the fibres of wood. The woods are also tested for toughness in a modern impact testing machine, for example, that of Hatt-Turner, under dynamic load conditions. Fibre stress at elastic limit, work up to elastic limit, and the maximum height a stick can endure the shock due to a weight of 50 lb. falling under gravity, are determined. Of course, all these data are relative, but, under the circumstances, only absolute data can be useful.



Olsen 30,000 lb. Universal Testing Machine at the Timber Testing Laboratory Dehra Dun (used for testing the Strength and Stiffness of hammer handles)

The writer wishes to be understood that this note is only an outline of work being done, or proposed to be done, at the Timber Testing Laboratory, and it will take some time before definite grading rules and specifications for the Indian woods are framed as the result of numerous tests. Though the Laboratory has not yet been able to conduct an exhaustive investigation in this direction, it has commenced work in this line in right earnest, and ere long the public will have ample material before them. Though the suitability of most of these woods above named are known to people locally, woods for this purpose will have no value in the western market until and unless we submit to them scientific data to convince them of the strength and suitability of Indian woods as compared with the recognised woods for handles like ash, beech and hickory.

The Laboratory will feel grateful to anyone who will kindly furnish any information of local interest anywhere in India and Burma bearing on this investigation, so that new tests may be made with a view to enlarging the scope of the investigation.

Some New Forms of Kilns

By Sir ARTHUR DUCKHAM, K.C.B., M.I.C.E.

Paper read before the Refractory Section of the Ceramic Society at Birmingham Oct. 3rd. 1922.

At the last autumn meeting of this section of the Ceramic Society, I promised Dr. Mellor I would place before you some designs of kilns which presented novel features. Although some of these are not specially adapted to refractory work, they may interest you, and will show the line of thought followed in our designs. My firm, as you may know, were primarily interested in the construction of plants for the manufacture of coal gas. We required for our purposes large quantities of high-class refractory material. The temperatures we wanted in the combustion chambers around our retorts were considerable, 1,350 deg. C. In the earlier stages we had the greatest difficulty in obtaining suitable material, in fact we suffered heavy losses through the failure of the materials used. But for these circumstances we probably should not have taken up research into, and manufacture of, refractory material.

In 1914 we were instrumental in the formation of a Firebrick Manufacturing Company, and undertook the design of a kiln that would ensure the proper burning of our refractory materials, together with a due economy of fuel. We were already closely in touch with the manufacturers in the Stourbridge area, and it was in that district we placed our works. The design of the kiln we erected was based on an existing plant in Germany, in the works of our agents, and during eight years has given general satisfaction. The kiln is of the continuous type, 16 chambers in all, each chamber 19 ft. 1½ in. wide by 16 ft. 9 in. long by 6 ft. 0 in. high to springing of arch, and 10 ft. 5 in. high to the crown of the arch. The chambers are arranged in two lines, with wickets on the outside only. There are four fireholes and bags to each chamber, the arrangement of firing being that generally known as semi-gaseous. The chambers are connected by flues under floor, for the passage of secondary air and heating gases.

The heat in goods already fired is utilised by passing the secondary air for combustion through several chambers behind the one being fired, and the products of combustion from the firing chamber travel through several chambers ahead, preheating the goods to be fired, before passing through damper to waste gas flue and chimney. Fig. 1 show the general layout.

One of the chief questions in design was to settle whether to heat the kiln by an outside producer or by four

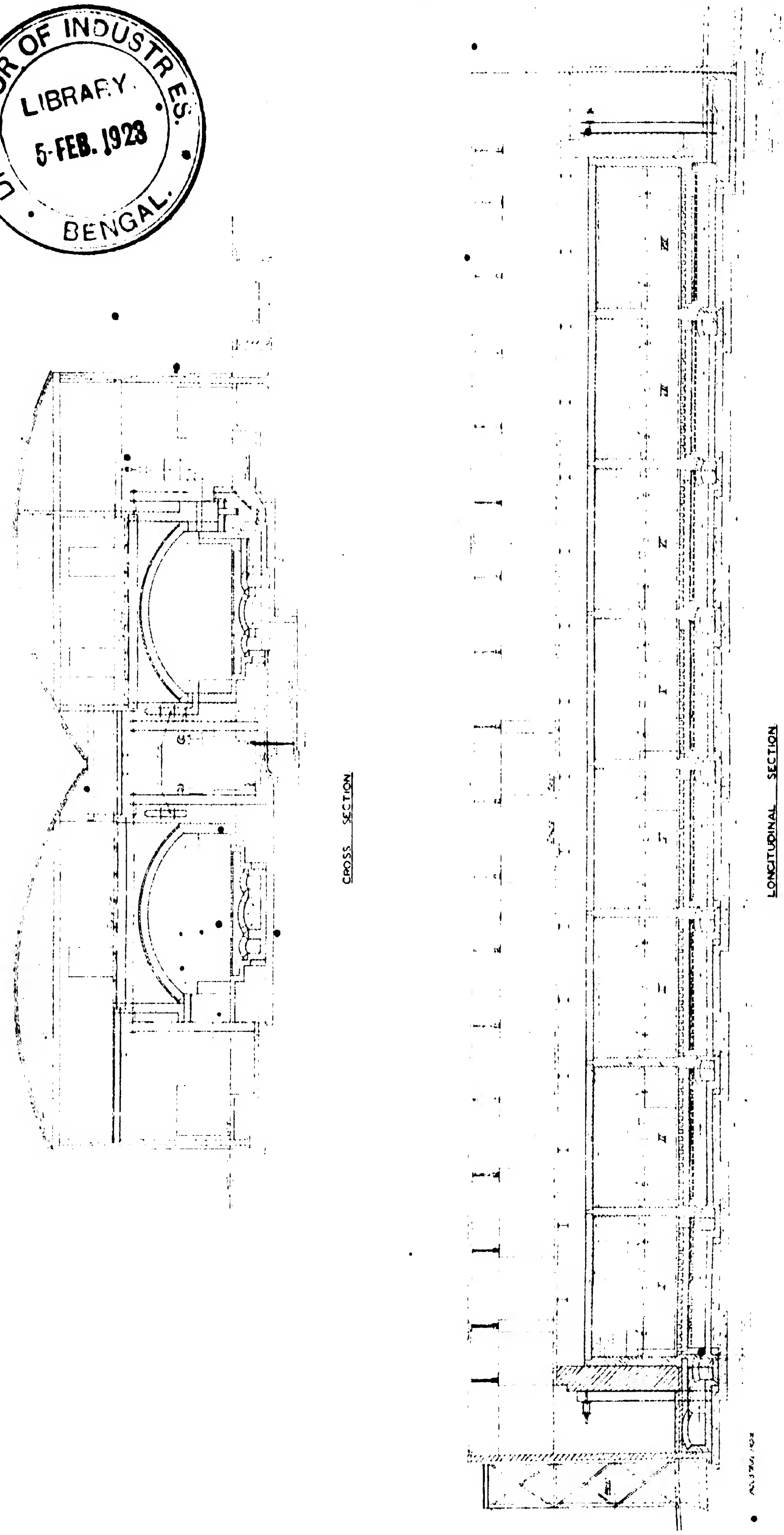


Fig. 1. General arrangement of 16 Chamber Kiln

individual fireholes to each chamber. In Germany the outside producer was used, consuming brown coal. We adopted the individual firehole system as we felt that the advantage of getting hot gas to the point of combustion in the bags would make up for the disadvantages attendant to individual fireholes. The results of working have justified our decision, and for this form of kiln, with individual bags and down draught, the firing arrangement adopted gives excellent results.

We burn firebricks in this kiln, made of local clay and reinforced with clay grog and silica. The bricks are burned till cone 13 comes down in the centre of the material, and this temperature is held for about 12 hours. Each chamber holds 60 tons of material, and we burn 14 to 15 chambers per month. The fuel consumption is 20 to 25 tons of coal per 100 tons of material burned.

I would now put before you the disabilities of this kiln as constructed. The chief trouble we had was to obtain sufficient draught to be able to work two chambers ahead of the firing kiln, in order to utilise the heat in the flue gases and two chambers behind to properly heat the secondary air. The chimney was 180 ft. high, but as the temperature of the flue gases was only 120 deg. F. entering the chimney, the pull on the main flue was insufficient.

The low temperature of the flue gases entering the chimney was partly due to the full utilisation of their sensible heat in the chambers ahead of the firing chamber, and partly due to air leakages, chiefly through the main dampers to each chamber. The dampers, as you will have noticed in the diagrams, were of the vertical cast-iron type, and it was found impracticable to keep these air-tight either around the sides or at the top. Consequently these dampers were replaced by cast-iron flap doors. This change ensured tightness at this point, and greatly improved the draught. We still found, however, that we could not under all weather conditions be certain of obtaining in a reasonable time and under all conditions the high temperature of burning which was absolutely essential in order to ensure that the shrinkage had been eliminated from the firebrick material. We consequently decided to dispense with natural draught altogether, and installed artificial draught, with most satisfactory

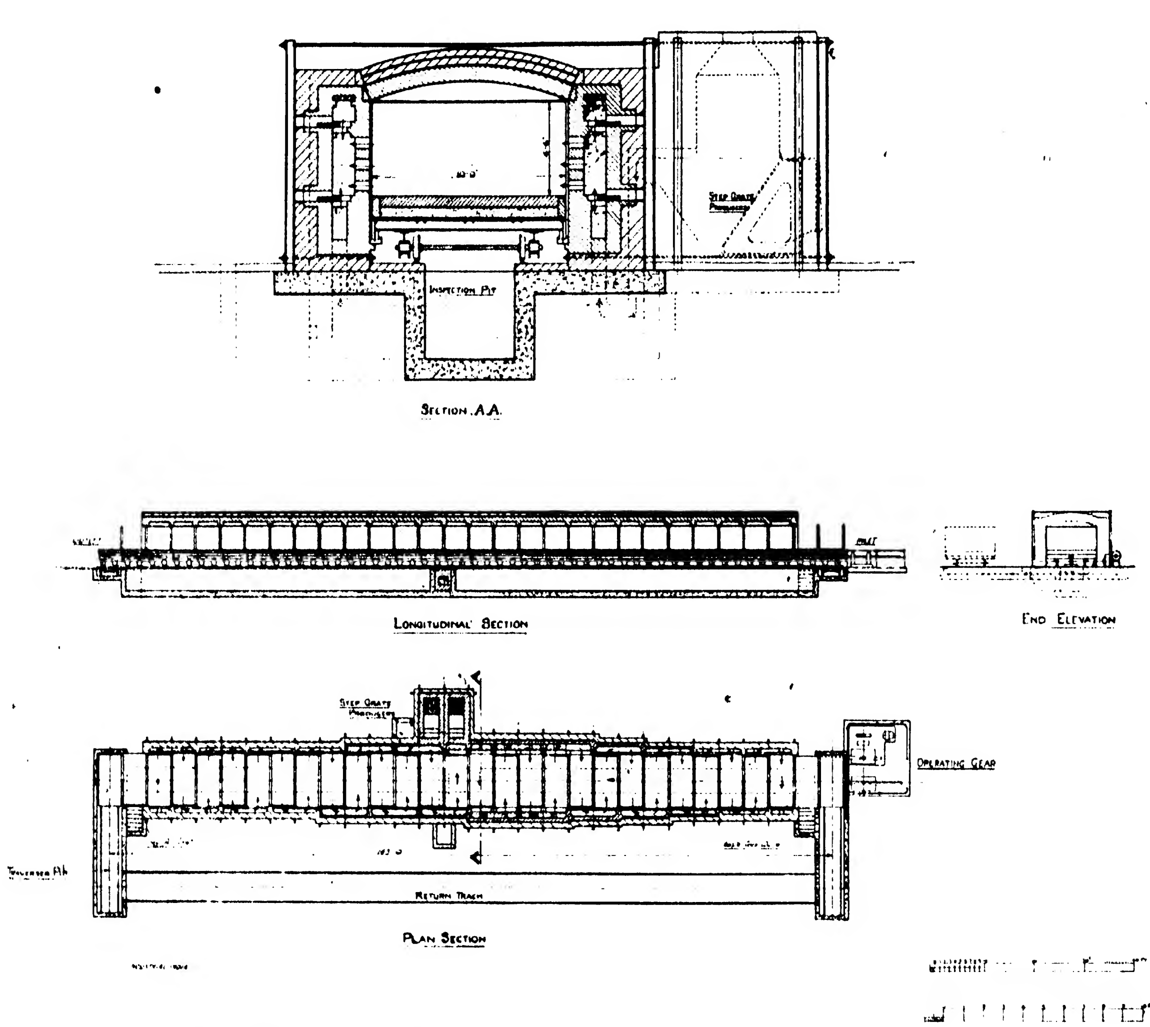


Fig. 3. Arrangement of W.D. Tunnel Chamber Kiln

results. The output from the kilns is greater, and we can be sure of the proper burning of the material. Recent tests on the product of this kiln show a shrinkage of between .25 per cent. and .75 per cent. when heated for two hours at 1,410 deg. C. actual.

Another difficulty we had to meet is inherent to the principle of a down draught kiln. The material at the top was burned to a higher temperature than the material at the bottom, and if the bottom temperature was raised to a proper degree, there was grave danger of the upper material being damaged. As we proposed to extend the output of this works, we had to consider and overcome this difficulty, and had to decide to depart from the principle of either an up draught or down draught kiln.

Fig. 2 will show you what we call the W.D. central bag kiln. Dr. Mellor has put this kiln previously before you, and it will therefore need but short description. Its advantages are:

(1) That even heating is obtained throughout the whole of the material of the kiln;

(2) That the bag forms no portion of the kiln proper, and so can be made of different material, and, further, it can be easily renewed;

(3) Proper combustion of the heating gases is assured;

(4) The brickwork forming the kiln proper is never subjected to the direct action of the heating gases during combustion.

A single chamber 15 ft. 2 in. wide by 16 ft. 8 in. long by 7 ft. 6⅝ in. to the springing of the arch, and 10 ft. 9⅝ in. to the crown of the arch has been constructed on these principles with an outside producer burning coal, and has given satisfactory results. We are shortly erecting a continuous chamber kiln on these lines.

The high temperatures necessary for the proper burning of refractory material, and the comparatively long period of soaking required at that temperature precludes, to a great extent, the use of other types of kiln than the continuous chamber for this purpose. In fact, for the burning of silica material, where an even higher temperature of firing and a longer period of soaking is essential, further modifications in continuous kilns must be made to obtain satisfactory working. We are at present designing a special kiln for burning silica bricks, and when these designs are completed I trust an opportunity may occur for them to be put before you.

The type of kiln which has always attracted the designer is the tunnel type. This type has not proved satisfactory for the burning of refractory material, but I venture to put before you two modifications of this type, as I believe consideration of them may interest you, and may lead to further developments.

The advantages of a tunnel kiln are very evident—saving of labour and fuel, and even heating and cooling of the materials. The disadvantages are:

(1) Mechanical.

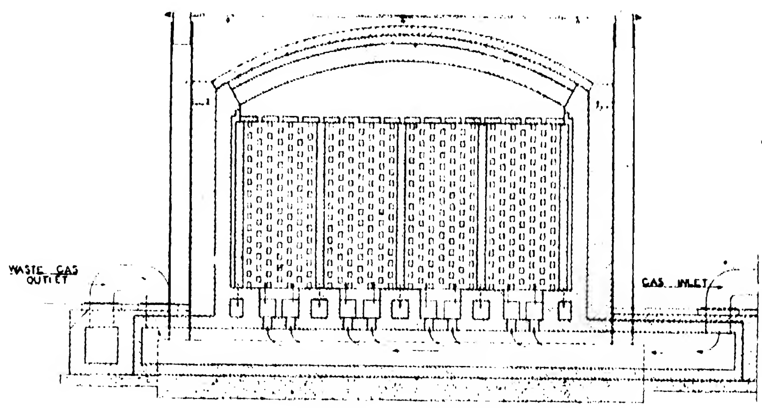
(2) The great length of the tunnel.

(3) The tendency of the heating gases to rise, and so cause uneven burning.

Dealing first with the open type of tunnel kiln, Fig. 3, we have endeavoured to overcome the difficulties in the following ways:—

Instead of allowing the gases to pass straight through the whole length of the kiln, cross walls are provided on each truck carrying the material, these cross walls registering with offsets on the kiln walls, thus forcing the gases to take a zig-zag path instead of a straight one. By this means we are able to reduce the length of the kiln from, say, 300 ft. to 130 ft. These cross walls really

(*Continued on page* 302)



CROSS SECTION OF CHAMBER KILN

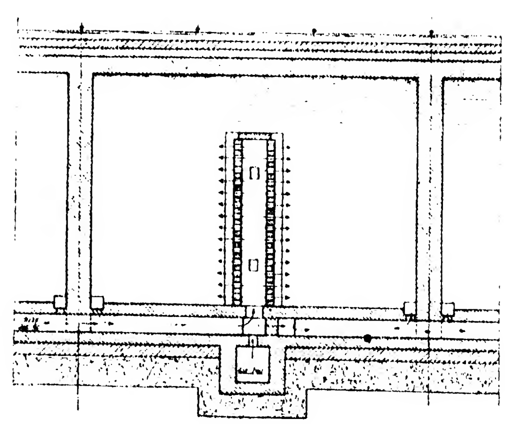


Fig. 2. Longitudinal Section W.D. Chamber Kiln
Arrangement of W.D. Chamber Kiln

Low Temperature Carbonisation (viii)

(THE "FUSION" ROTARY RETORT)

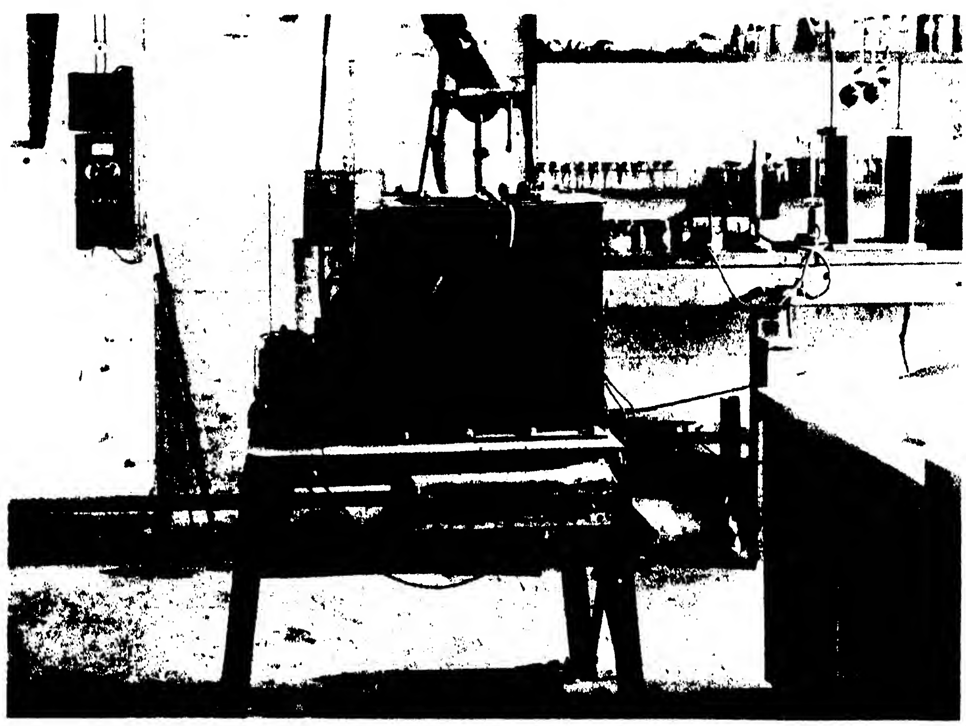
By DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min.E., Mem. Am. Soc. M.E., A.I.Mech.E., etc

THE "Fusion" rotary retort is the invention of Mr. Stainer Hutchins, M.I.E.E., A.M.I.M.E., and is controlled by Messrs. The Fusion Corporation Ltd., whose Testing Station is situated at Middlewich, Cheshire, Mr. Stainer Hutchins being the Chairman of the Company.

The "Fusion" retort is of the horizontal continuous type, and the design is based on the following facts: In the first place, in order to get the maximum yield of oil from coal, shale, or other similar fuels, it is necessary to carbonise the material in a comparatively fine state of division, say all through a ¼ in. mesh. This gives an increased yield of oil, because a lower carbonising temperature can be used, since the heat penetrates quickly to the whole charge, and there is much less "cracking" and decomposition of the lighter oils. Further, the thickness of the layer during carbonisation should not exceed a few inches, because of the bad heat conductivity of coal, and also to allow of the free evolution of the oil vapour, and Messrs. The Fusion Corporation Ltd. maintain, in addition, that during carbonisation the material should be continually turned over, so that a fresh surface is constantly exposed to the hot surface of the retort, which is of further assistance in overcoming the low conductivity of the coal, and assures even heating with a regular evolution of oil vapour. Also it is maintained that the material should be gradually and evenly, but quickly, raised to the maximum carbonisation temperature in not less than 20 minutes, whilst the whole process should be continuous, to reduce labour costs.

The special feature of the "Fusion" retort is a heavy internal "breaker" based upon the claim of the inventors that during continuous carbonisation in a horizontal retort, it is impossible to prevent the softened material fusing and caking on the heated surfaces of the retort, forming a hard scale or deposit, which reduces the efficiency of the retort by lowering the heat conductivity, and finally blocks up the retort. Allied to this difficulty is that of the tendency of the carbonising material to form lumpy masses, which, in ordinary simple continuous retorts, are very difficult to break up.



Laboratory Retort capable of treating about 5lbs. of material. The illustration shows the end removed with breaker resting on bottom

The "Fusion" retort substantially consists of:—

(1) A long horizontal retort revolving in a furnace, heated by producer gas, with stationary feed chamber.

(2) The producer, combustion chamber, and furnace, that is, the apparatus for heating the retorts.

(3) The oil and other condensing plant for treating the gaseous and volatile products evolved.

(1) The retort consists of a revolving steel cylinder or tube, which rotates in a brick furnace, and is shown in detail in Fig. 1, and also

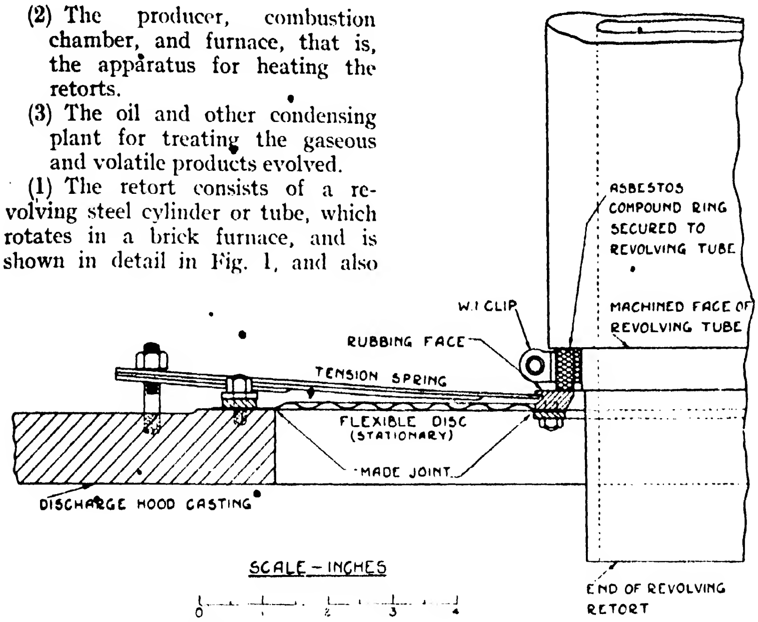


Fig. 2. Details of Flexible Joint

Fig. 2. At each end is mounted round the cylinder a steel path ring or tyre, which in turn rest upon two or more small rollers, so as to permit of the easy rotation of the cylinder, which is effected by any suitable power available through spur or other gearing. The dimensions of a small retort for a capacity of 5 tons of coal per day of 24 hours, as installed at the testing station at Middlewich, is 25 ft. long and 2 ft. 6 in. diameter, the retort being supplied in standard sizes of 2 ft. 6 in. to 4 ft. diameter, and 25 ft. to 100 ft. long, with a capacity of 5 to 100 tons of coal per 24 hours. The horse-power required to drive the retort is very small, about 1 B.H.P. for the 5-ton size, and the speed is extremely slow, about 5 to 7 revolutions per minute. The coal is pulverised so as to pass through a ⅛ in. mesh, and is conveyed automatically to the feed hopper (A) (Fig. 1) at one end and passed, by means of hand-adjustable mechanically-operated gear, through an air-tight coal feed valve (B), the pulverised material travelling along the revolving cylinder and into the discharge hopper. Inside the retort is loosely placed (not separately driven)

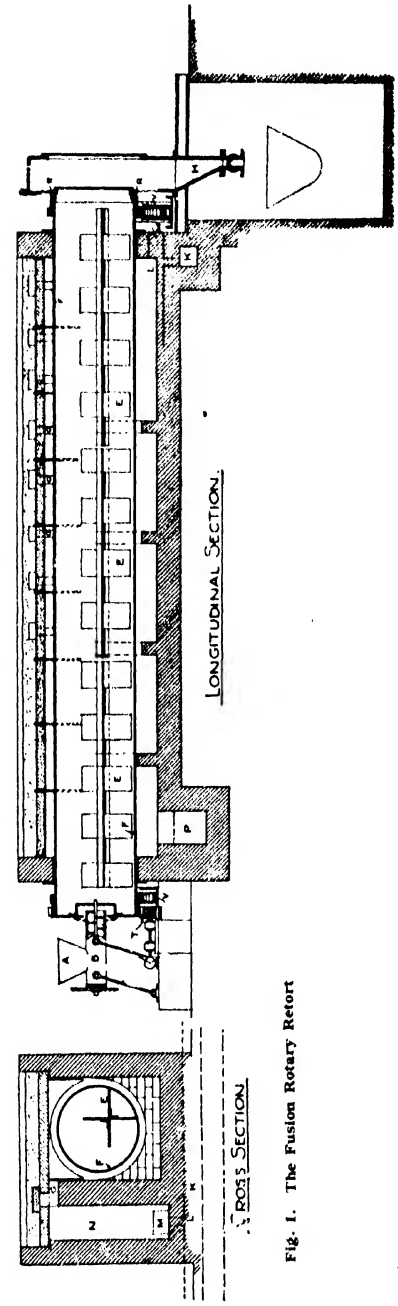


Fig. 1. The Fusion Rotary Retort

a long "breaker" (E), which is somewhat similar to a much elongated paddle wheel, with four or six arms, depending on the size of the retort. This breaker is constructed of thick iron plate, weighing for the 5-ton retort about 250 lb., and continually falls over on the edges of the blades, as seen in Fig. 4, in so doing giving a powerful hammer blow, and so grinding and crushing the carbonising material. It will be understood that the edge or blade of the breaker does not come into direct contact

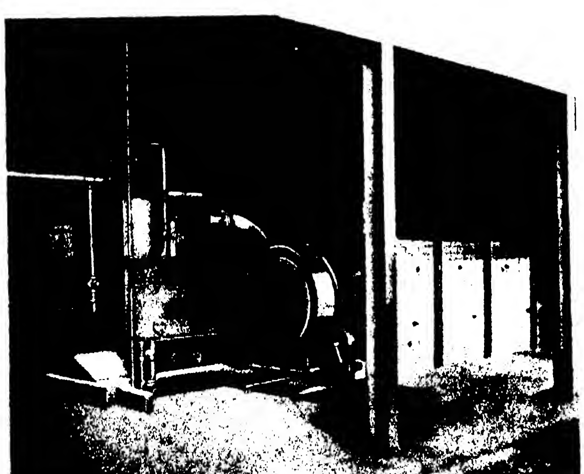


Fig. 3. End view of Retort and Oil Vapour Condensing Plant

Corner of Laboratory showing Laboratory Retort capable of treating about half-a-pound of material

with the metal of the cylinder, but falls only on to the charge as it is being carbonised, and therefore the retort in action is not noisy, but practically silent, only giving a regular gentle thud. The action of this breaker is peculiar, but very effective, and so far the inventors claim they have not had a single blockage of the retort, although they have tested numerous caking and swelling materials of the most difficult character, such as Esthonian shale. It is remarkable also that the presence of the breaker, apart from the mechanical advantages already discussed, results in 12 to 25 per cent. increased yield of oil and this is seen also by the very low yield of gas, and the cause seems to be that a fresh surface of material is being continually exposed to carbonisation by the shock and concussion.

A great difficulty in the employment of revolving cylindrical retorts up to the present has been that of obtaining a gas-tight gland that will work without friction. This the inventors claim to have overcome in a very simple manner. As seen in Fig. 2, they employ a thin sheet iron ring the full width of the cylinder, made additionally flexible by circular corrugations, the inner edge of this ring being pressed against an asbestos ring by springs, which in turn is mounted upon the rotating retort, and the outer edge of this sheet iron ring is fixed to a stationary hood or chamber which covers the discharge end of the retort, the gas and oil vapour outlet being fixed on this hood.

(2) The producer used to supply the low grade gas for heating may be of the heating producer type or of the simple type, the former requiring steam under pressure, and the latter simply a wet grate, etc. In certain cases, nearly always in small installations, the gases for heating the retort may be obtained from an ordinary hand-fired grate, and the residual low temperature fuel may be used, or, alternatively, any other suitable fuel available.

The hot gases from the producer are conveyed to the combustion chamber, which, as seen in the illustrations, is rectangular in section, lined with firebrick, and reinforced on the outside with heavy stay bars. In this combustion chamber the producer gas meets an air supply on the usual lines to assure proper combustion, and the flames pass through a number of orifices placed in the wall between the combustion chamber and the furnace, and by this means the carbonising temperature at any part of the cylinder can be controlled at will by means of dampers in the gas and air supply. The products of combustion pass down the cylinder, travelling towards the feed end of the

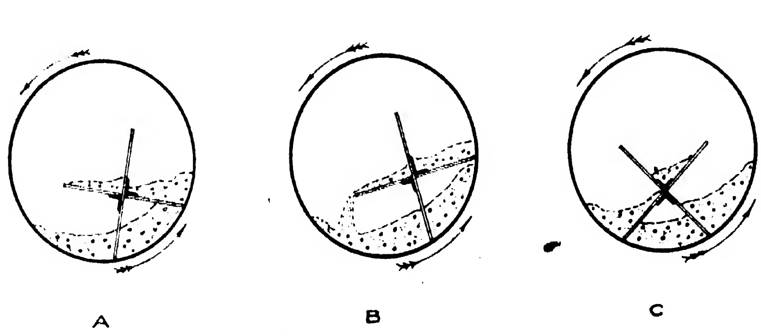


Fig. 4. Showing action of Breaker

retort, and finally passing by means of an exit flue to the chimney. Various sight-holes are provided in the brick-work for the purpose of watching or testing temperatures, and the carbonising temperature is arranged on a gradient generally commencing at the inlet end of the retort at 840 deg. F. (450 deg. C), and gradually falling to 390 deg. F. (200 deg. C.) at the outlet end.

The hot gases leaving the retort could, in some cases, with advantage be used for pre-heating or drying the coal before being carbonised, although the amount of the total heat going to waste is small, whilst the amount of heat required to heat the retort is equivalent to about 8 per cent. of the coal carbonised, although, of course, expensive coal would not be used for the purpose.

(3) The condensing plant for the gaseous and liquid products is seen at the end of the retort in Fig. 3, and is of a simple character, consisting of a number of wrought-iron or steel tubes cooled by water or by atmospheric means, the condensed oil being run into a suitable receiver, and the rich gas passing on to a suitable purification plant and gas holder.

It is the intention to work the retorts in batteries, and the Fusion Corporation are prepared to supply standard units of from 5 tons to 100 tons throughput per 24 hours, but they advise that for a given output at least three units should be employed, that is, assuming the throughput required was 150 tons per day, they would prefer to instal three of their 50-ton units in preference to two 75-ton units. These units would preferably be erected side by side, and supplied with gas, say, from one producer, preferably of the simple type, having regard to the lower cost of operation of this type of producer.

As typical of the yields obtained with the "Fusion" retort, the following are figures in the first place for shale and torbanite. With the Esthonian shale most of the oil comes off between 520 to 840 deg. F. (275 to 450 deg. C.), together with about 2,500 cubic feet of rich gas, about 900 B.Th.U. per cubic foot, without stripping. With the Kimmeridge shale the temperature of carbonisation was 570 to 750 deg. F. (300 to 400 deg. C.).

	Galls. oil per ton (undried) materials, exclusive of oil in gas.	Specific gravity of oil	Per cent. volatile matter in residue	Per cent carbon content in residue
Esthonian shale	73.6	0.921	4.96	10.60
Nova Scotia torbanite ...	51.8	0.849	6.10	9.50
Australian torbanite ...	131.7	0.854	13.95	26.00
Kimmeridge shale	52.5	0.980	6.85	20.10
English shale	61.82	0.920	2.69	67.67
East African shale	112.89	0.864	2.58	47.72
Tasmanian torbanite ...	62.72	0.920	1.30	13.85

Taking now the low temperature carbonisation of coal, a typical result from 1 ton of coal of the following analysis :—

Ash	4.52
Water	1.45
Fixed Carbon	57.35
Volatile matter	36.68

carbonised at 840 deg. F (450 deg. C.) maximum is :—

(1) Gas	1,830 cubic feet.
(2) Oil	37½ gallons.
(3) Residue ...	74% = 1,657 lb.

Another Corner of Laboratory

The gas is of very rich quality, from 750 to 900 B.Th.U. per cubic foot, and will, of course, find a ready use for many purposes. The primary object of the "Fusion" retort process is the maximum production of oil, and a very high yield is claimed, because of the rapid carbonisation at comparatively low temperature, the almost complete absence of cracking, and the action of the breaker already described. The result of these conditions is that practically no ammonia at all is formed.

Smokeless Fuel

The residual low temperature smokeless fuel, being in a comparatively fine state of division, as well as soft and friable, is, of course, not suitable for direct use as household fuel. The amount of volatile matter present under normal conditions is 7 to 10 per cent., but this can be varied at will by altering the temperature conditions of the retort, whilst the heating value is about the same as the original coal. For household purposes it will be briquetted with the usual pitch or other binder, the cost of briquetting being about 1/6 per ton, forming a very efficient smokeless fuel, burning with a high emission of radiant heat. The fuel as delivered by the retort also lends itself particularly well to pulverised fuel firing for steam generation, and for use in producers.

As regards the cost of installation and operation of the "Fusion" retort, the following are approximate figures :—

	£
Installation, composed of three 20 ton "Fusion" retorts, giving a throughput of, or capable of treating, say, 60 tons per day (24 hours), of slack, or the like material	1,200
Driving arrangement, including automatic feed conveyor and elevator, for the material, but not including bunkers	450
Combustion chamber and simple producer	590
Sundries, contingencies, not including oil, condensers	360
	£2,600

The usual accessories in the way of buildings and foundations, coal washing and crushing plant and by-product recovery, are, of course, common to all low temperature carbonisation processes. As seen from the above figures, the cost of the retort plant alone is about £45 per ton of coal carbonised per 24 hours, an extraordinarily low figure.

The labour required is extremely small. One man could operate three retorts if necessary, but with two men, the crushing and condensing plant could also be included. This gives a labour cost of only 1/3 per ton of coal carbonised, and repairs, maintenence, and stores, would increase the figure to 1/6 per ton.

Whilst it is claimed that this retort has proved its advantages in the treatment of materials low in fixed carbon, such as oil shales, torbanites, cannels, lignites, etc., the performance has been equally favourable in the case of coals containing a high percentage of carbon, and particularly in the case of materials which have different caking and swelling properties, such as, for example, "Kent" coal, which swells to 2 to 2½ times its volume. Thus a coal having swelling properties of approximately twice its original bulk was obviously unsuitable for coking purposes, and owing to its physical nature, it was unsuitable for storing or carrying purposes, as it very quickly fell to dust. Its market value, therefore, was low, and the solution of the difficulty was thought to be briquetting, but the swelling properties prevented this also. However, by coking 80 per cent. of this coal in the "Fusion" retort, and mixing the residue with 20 per cent. of the original coal, an ideal briquette was obtained, and the flexibility of the "Fusion" retort, combined with the low capital cost and large throughput are obviously very strong points in favour of the process.

The Value of the Small "Diesel" Engine

One of the great practical advantages of the "Diesel" engine is that it is almost as efficient in very small units as in large installations. One of the well-known defects of the steam engine is that in the small units in ordinary use the efficiency is very low, so that, whilst in a large steam engine over, say, 750 H.P., to which continuous attention can be given, figures like 11 to 12 lb. of steam and 1¾ lb. of coal per I.H.P. may be obtained, in small steam engines the results are nothing like so good. Taking, for example, all the steam engines in use throughout the world, the great majority are small engines running under bad or only medium conditions as regards care and attention, and the average performance figure is only about 5 lb. coal per I.H.P., in spite of the fact that some steam engines are obtaining results like 1¼ lb. As regards steam turbines these cannot be used economically for sizes much less than 750 H.P., because of the comparatively high cost of construction of such small units. But the "Diesel" engine shows nothing like these differences for even very small units, and the crudest labour and attention. Thus a high-class "Diesel" engine of large size, say 750 H.P., gives results like 0.42 to 0.45 lb. oil per B.H.P., whereas a small engine of, say, only 150 to 200 H.P., will rarely give figures lower than, say, 0.50 to 0.60 lb. oil.

The tendency in America, where the "Diesel" engine for land installations is in particular favour, because of the comparatively low price of oil, is to adopt the 2-stroke cycle principle for the smaller engines. As typical of such American "Diesel" engines are the productions of the Nordberg Manufacturing Company, which are of the slow-speed, 2-stroke cycle, full "Diesel" type, with a direct driven 3-stage air compressor and a double-acting scavenging air pump, driven by separate cranks from the crankshaft. Various parts are water-cooled, such as the cylinders, cylinder heads, crosshead guides, pistons, and exhaust pipes. This engine is built in standard sizes of 3, 4, 5 or 6 cylinders, each cylinder having a uniform output of 110 B.H.P., a 3-cylinder engine driving, for example, a 225 K.W. generator. The cylinder bore is 15 in., the stroke 20 in., and the mean effective pressure 55 lb. per square inch at the full load speed of 225 R.P.M., the weight being 260 to 280 lb. per B.H.P. Almost any variety of fuel oil can be burnt, and it is claimed that the performance figure is practically equal to that of the largest installations—0.45 lb. oil per B.H.P.

TRANSPORT

Conducted by "M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH :: :: THE MANAGEMENT AND CONTROL OF RAILWAYS :: :: ::

Recent "Garratt" Patent Locomotives

(*Continued from page* 275)

The following notes record some details of the recent "Garratt" type locomotive

THE South African Railways have recently received from Beyer, Peacock & Co. three experimental classes of "Garratt" engines; one class consisting of three engines for the 2 ft. gauge sections of these railways, the second class being the 50,000 lb. tractive effort—at 80 per cent. boiler pressure—engines mentioned in the earlier part of this article, and the third class an engine to give the maximum tractive effort obtainable with six coupled axles on lines laid with 38 lb. rails.

The engine develops 50,000 lb. tractive effort. The wheel arrangement is 2-6-6-2; the cylinders, motion, coupling and connecting rods, wheels, axles, axleboxes, spring gear, brake gear and the truck being exactly the same on each engine unit. The enormous boiler is carried by a girder frame built up of two side plates suitably cross stayed. At each end is the top portion of the pivot which fits into the corresponding bottom portion on each engine unit. The girder frame is fitted at each end with side bearing blocks resting on similar blocks on the engine unit, these blocks being on the transverse centre lines of the pivots.

The ball joint, at each end, for the live steam pipe is attached to the underside of the top portion of the pivot casting directly on the centre, so that the ball has the minimum possible movement. The exhaust steam ball is placed at one side of the live steam ball, a slip joint being provided on the pipe to allow for the slight longitudinal movement.

The steam is conveyed to the cylinders by carefully lagged pipes; similarly the exhaust steam from each pair of cylinders passes through lagged pipes and finally combines in the blast pipe. In this, as in all the South African "Garratts," stop valves are provided on each steam pipe in case of failure of either pipe.

The draughting arrangement of a very large boiler is not a simple problem, but with this engine the proportions adopted have been most successful, the boiler steaming with great freedom on a relatively low fuel consumption.

Reversing Gear

The hind unit carries a combined water tank and coal bunker, the shovelling plate of the latter projecting into the cab; the front unit carries a plain water tank. The two tanks are connected by a large levelling pipe running along the outside of the girder frame with flexible connections to the pipes under the tanks. Shut-off valves are provided under each tank to isolate either should occasion require.

The reversing of the engine is performed by a steam gear on this large engine, but generally screw gear is fitted, this operating both sets by intermediate reversing shafts placed above the pivot castings, the arms of these shafts, to which are connected the reversing rods to the shafts at the expansion links, being placed central, so that the movement of the engine bogie has but small effect.

In spite of there being 2,654 sq. ft. of heating surface and a grate of 51.8 sq. ft., it is built up of only six steel and three copper plates, all of which are of plain outline. This, of course, excludes the home in the list of plates.

A comparison of the depth and volume of the firebox of this, or any, "Garratt" engine boiler, with that of, say, any Mallet engine is very instructive.

The brakes are operated by steam, in conjunction with vacuum to the train, while a hand brake placed in the usual position in the cab operates the brake on the hind unit only.

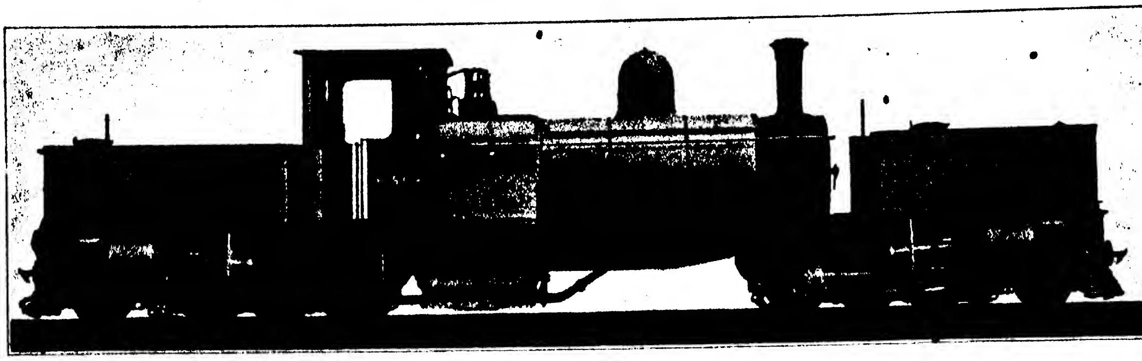
The cylinder cocks are opened and shut by steam cylinders on the engine frames.

The grate of this engine consists of rocking finger bars and a front drop grate. The ashpan is of the semi-hopper type with sliding dump doors underneath to enable the ashes to be dropped, while the engine is running, after, of course, they have been well slacked.

As far as possible, South African practice has been introduced in this, as well as the other "Garratts" for these railways. The boiler is fitted with a superheater of the Marine & Locomotive Superheater Company's pattern, fitted with automatically-operated dampers. The cylinders and valves are lubricated by Wakefield mechanical lubricators; the steam sand apparatus is of Gresham & Craven's pattern.

The second class of engine for these railways is of the 2-6-2-2-6-2 type, and was designed to supply the maximum tractive effort possible on the lighter sections of these lines where the rails weigh only 38 lb. per yard. The inclines on these sections are frequently 1 in 40, and 5-chain curves are frequent.

While this engine is only of moderate dimensions when compared with that previously described, it has a very high tractive effort for an engine restricted to 7½ tons axleload and



six coupled axles, the tractive effort being 18,290 lb. at 75 per cent. boiler pressure.

This engine is fitted with a Robinson superheater, Wakefield mechanical lubricator and generally similar fittings to the larger engines, the reversing, however, being by screw gear.

The third class for the South African Railways consists of three 2-6-6-2 engines designed for operating mixed trains on the 2 ft. gauge feeder lines in Natal and elsewhere. The lines combine gradients of 1 in 30 with 150 ft. and even less radius curves.

The axleload is restricted to 6½ tons, the tractive effort at 75 per cent. boiler pressure is 15,870 lb.

Apart from the fact that these engines have no superheater, they are in general smaller editions of the other "Garratt" engines of these railways, possessing all the special features of the type we have detailed in the description of the largest engines.

The brakes are steam operated on both engine units, while the hind brakes can also be applied by hand power. Reversing is by hand lever.

These are very interesting examples of the possibilities of the "Garratt" type locomotive on light feeder lines, where sharp curves and heavy grades are common, and on which the traffic has grown beyond the capabilities of ordinary type locomotives.

The Need for an All - India Gauge Policy

By F. G. ROYAL-DAWSON, M.Inst.C.E.

We publish below part of the discussion on the above paper, which appeared in our September and October issues.

THE Chairman (Sir R. W. Gillan) said that personally he did not feel very competent to contribute to the discussion, especially in the presence of various eminent railway authorities, but he might make a few remarks, strictly as a layman. The first thing he would like to do was to draw a necessary distinction. India was a museum of railways. It contained everything, from the lordly 5 ft. 6 in. to the toy 2 ft. That day he had heard that some authority in Bombay proposed to make a 4 ft. 8½ in., just in order, he supposed, to complete the collection. But these railways had in common nothing except their mere rails. A discrimination must be made between classes, and he thought the two main classes were these: (1) lines of long distance traffic or trunk communications, and (2) what might be called local lines, whether described as "feeders" or, as someone had called them, "railed roads." These two classes had to be kept very distinct, or mistakes would be made. For the local lines it might be advisable to aim at connected systems, or possibly at a network of light rails all over the country, but in any case continuity of gauge was not in their case a paramount consideration. In the case of main lines, or railways proper, many people thought that gauge was paramount, and it was perhaps at this point that the difficulties had originated over the gauge question. The origin of the difficulties might, that is to say, lie in the fact that the metre gauge was a possible gauge for both sorts of railways. He would not describe it as falling between two chairs; rather it seemed to sit on both chairs, or perhaps one might say that it was difficult at times to be sure on which chair it was sitting, for it served both for main line communications and for feeder lines. To vary the metaphor, they might say that it made the best of both worlds, and he thought the issue before them was very much in this sense, that adherents of the metre gauge said that it was a universal gauge available for either class of railway, while the adherents of the broad gauge said that it was not the best for either. The two main questions as they appeared to the speaker were these. In the first place, was continuity of gauge a paramount consideration in the case of railways proper? Was it something to which they ought to subordinate other advantages, it might be to a considerable extent? Many of the arguments that had been brought forward in India seemed to indicate that it had this character, but in practice it had been treated as of comparatively little

importance. Then, in the second place, the question was which was the preferable gauge for the main system of railways, assuming that there should be one? The arguments which had been advanced here, seemed to favour a broad gauge, but on behalf of the metre gauge it was answered that the metre gauge, at any rate, sufficed for the requirements of main line communications, and the question, therefore, transferred itself to this, whether the advantage of the broad gauge was of sufficient extent to counterbalance other considerations. He thought the views formed on these two questions would largely influence the decision taken on any particular project put forward, whether the construction of new lines or the provision of larger capacity on existing lines, but they would be complicated by other factors—in particular, traffic considerations which were of vital consequence to the metre gauge lines would often be found to have a far-reaching effect. Mr. Royal-Dawson had said that in the long run the broad gauge was bound to predominate. He thought there were two facts which went against that conclusion. The first was that the metre gauge systems, unlike Government, had a perfectly definite policy, and the second was that, also unlike Government, they were always prepared to finance what they considered desirable. The outlook generally, therefore, for this gauge question seemed to be as uncertain and as unsatisfactory as its past history had been. He thought that something ought to be done. Mr. Royal-Dawson had proposed legislation, and the speaker quite understood the considerations that had led him to that recommendation. But he was not sure that in the case of the Government of India legislation would be appropriate, seeing that they would be laying down rules, not so much for private companies as for themselves, and in any case he would say that it was clear that in spite of all the time and discussion given to this subject, it was not yet ripe for legislation. He would turn, therefore, to the report of Sir William Acworth's Committee on this subject, which said:—"Thorough investigation of the gauge problem is urgent at this moment. We think that the situation as it at present exists, must be faced as a problem affecting the whole of India, and examined from the engineering, operating, and financial side by a special commission of two or three of the first experts who can be found after careful search not in one country only." A commission of this kind would be able to lay down an authoritative policy which the Government would be able to carry out. If he (the speaker) were on the Railway Board still, he would welcome the assistance given by a body such as was proposed by Sir William Acworth's Committee in almost every project that came before the Board.

Lord Montague

Lord Montague of Beaulieu, K.C.I.E., C.S.I., said he had recently returned from India, where he had been studying railway systems and railway questions in general, including this very gauge question, and he must confess that, after considering the subject generally, his conclusions were more in accord with Sir Robert Gillan than with the reader of the paper. He was inclined to take this view, not only on account of what he considered its inherent soundness, but from the point of view of finance, which in these days was the most important consideration in railway construction in India. India proposed to borrow a large sum, to be spread over the next five years, for the rehabilitation of the railways, which at the present moment could not be described as being in anything like a fit state, either to carry the existing traffic or, still less, the traffic of the future. Therefore, the problem resolved itself into this: having raised the sum in question, how could the money best be spent? He did not think that an impartial judge would advocate that any considerable proportion of it should be spent on making the gauges more uniform. What Sir Robert Gillan had said was perfectly true. The traffic in bulk from ports was distributed up country in the main and at present moment by the standard gauge. The standard gauge went to every main port in India. It carried something like 80 per cent. of the traffic. The lesser gauges distributed and collected that traffic more or less in a radial fashion, and at various stations all over India on these narrow gauges, he was struck by the very small amount of traffic which did pass over these narrow gauge lines. He spent one day examining a local line which ran eighty miles west from Cawnpore, with a view to suggesting the running of rail motor cars, and he was impressed there with the very small amount of traffic. He was told afterwards, that it was affected somewhat by strikes that were going on to the eastward but even so, there was no doubt that that line was not employed to anything like its full capacity, and there was room for a good deal more traffic to pass over it. When one came to the construction of new lines, he would rather see a road as a feeder to a railway than the construction of more small gauges; and the modern use of motor vehicles, with the less handling which they entailed at the points of origin and destination, was really an argument for a diminished construction of feeder lines, and a greater construction of roads to feed the main line station. With regard to other points in the paper, he would ask the reader to consider whether the analogy of France was not worth studying. In France, the main lines of railway had a 4 ft. 8½ in. gauge, which was the standard continental gauge, but there were also very successful light railways in the north of France for agricultural purposes, in the east for minerals, and in the south for passengers and goods. To take one railway which ran on the Riviera, from St. Raphael to Toulon, it would have been impossible to have got a standard gauge, with all the necessary paraphernalia of stations, signals, and so forth, on this line, but although it was worked in a casual way, it was worked quite cheaply and efficiently. It was really a "railed road." The French students of railway matters had always told him that they regarded these lines purely as feeders, rather than railways proper. To attempt to reconstruct the metre-gauge railways of India would entail a very large sum of money, and to attempt to do it when there were so many other urgent things to do, such as the provision of heavier locomotives and other important matters, would be a waste of money. He thoroughly agreed with the reader of the paper in some of his statements. There was no doubt whatever that the break of gauge at some of these points was a very serious matter to the public, even more than to the railway companies. It did not necessarily affect dividend-earning capacity, but the delay in some cases prohibited perishable traffic, and in these days, when the Indian coolie was not as tractable as he used to be, and his labour was very much more expensive, the handling and transhipment of goods at these interchange points was a bigger problem than in the past. As a remedy, it might be possible to use road wagons on crocodile trucks, or trucks with very low platforms, and tranship them from one truck to the

other on the railway. This was done now on the London and South-Western, and also on the Continent. Then, again, there was the use of transporters at stations. In fact, he did not admit that all the means of interchange of traffic had been exhausted. Of course, there was no doubt whatever that, as the reader of the paper put it so well, given a certain tonnage from a certain distance and a certain number of passengers, they were conveyed more economically on a 5 ft. 6 in. gauge than on smaller gauges. They must all deplore the fact that the gauges were made originally of such a diverse character, and he could only hope that, chiefly on the grounds of relative urgency, none of the borrowing for the railways of India would be spent on the alteration of gauges. But he admitted to the full that at some time in the future this gauge question would have to be considered.

Sir Wm. M. Acworth

Sir William M. Acworth was quite sure that they would all be grateful to Mr. Royal-Dawson for his valuable paper. In one particular the best was the enemy of the good, and that was his map, in which he had tried to show too much. If his map had merely shown the metre gauge and the 5 ft. 6 in. gauge, it would have brought out what he had described so well in his paper—the way in which blocks of metre gauge were intersected by and cut across by lines of the other gauge, and so would have demonstrated what an unsatisfactory position had been reached. He hoped that the map might be simplified and re-drawn when the paper was published. He (the speaker) was not an engineer, and he wanted to confine his attention to the subject of the paper as headed, which was not "The Proper Gauge Policy," but "The Need for a Policy." If the map he had asked for were in existence, it would be enough to hold it up in demonstration of that need. If his recollection was correct, the Indian railways began about 1851-1855. He was rather surprised that the big English engineers as early as 1855 did not see that 5 ft. 6 in. was not right to start with. By that time he would have thought they would have understood that 4 ft. 8½ in. was good enough. He wanted to put himself in the position of the man who first started the narrow gauge. He was quite sure that that man said that the people who started the 5 ft. 6 in. were wrong. He must have had that in his mind, and have decided that, because they were wrong, he was going to do something else. To-day he did not think anybody would deny that the people who had produced this crisscross system were wrong. The question was, however, ought we, in 1922, to have a policy? Mr. Royal-Dawson and Lord Montagu had spoken of the large sums invested. But we were only at the beginning of expenditure on Indian railways. The whole capital investment so far was only £400 millions, one-third of the capital invested in the railways of Great Britain There were fewer miles of railway in India, for a population of 300 odd millions, than in Canada for a population of eight millions. India was only beginning to make its railways. It had got to make a vast number more. Surely it was necessary to have a policy before they went any further. His esteemed colleague, Sir Henry Burt, had said, "For heaven's sake, don't start out to get a policy. It will be made the excuse for the Finance Department to refuse every penny of money to go on with, on the ground that the policy is not yet forthcoming." The speaker believed that it was desirable to get a policy before building any new lines, but the amount of which Lord Montague had spoken as about to be borrowed by the Government of India was pledged for improvements of the existing system. After these improvements had been effected, they might begin to talk about extensions, and then would be the time to get a policy. He did not think people had appreciated the absolute non-necessity for the 5 ft. 6 in. gauge. Before he went to India he travelled a good many thousands of miles on the South African 3 ft. 6 in. gauge, which was not very much better than 3 ft. 3 in. He travelled in perfect comfort, with sleepers and diners and so on, and on that gauge in South Africa they ran trains as heavy as the heaviest train he could find in India. The heavy trains in India from the coal-fields down to Calcutta were no heavier than those run in the Transvaal on 3 ft. 6 in. On the other hand, take the 4 ft. 8½ in., it was going to be a long while before anybody proposed to take a train heavier than, say, 17,000 tons—a load that has actually been hauled by one engine in America—over these lines, so that it seemed to him that the thing was open for discussion, and it had to be discussed from the point of view, not of what was done on the 5 ft. 6 in. or on the 3 ft. 3 in., but of what might be done. With what Mr. Royal-Dawson said about transfers he was absolutely in agreement. Nearly all the witnesses before his Committee said that they were short of trucks. They were not short of trucks a bit, there were plenty of trucks to move the traffic if they could only move the trucks. You must tie up trucks and tie up roads when you come to tranship on a large scale. Why did the little original short-line railways in America and England come together in big systems? It was because they had not discovered in those days that it was possible to book traffic from one company to another on a clearing-house system. It was equally impossible to conduct a large traffic satisfactorily if there was unloading from one gauge to another. In theory they might be told that it was possible to take stuff out of one truck and put it into another in a certain number of hours or minutes at a certain number of pence or annas per ton. But that did not happen in practice, and never had done, and never would. That was the evidence all over the world. They always suffered from this break of continuity. It was worth almost anything to a railway man to get the power of working through. The best proof of it was that the Indian Government was putting up a broad-gauge line through the Khyber Pass. They knew perfectly well that they must not have a break at Peshawar, or they would have congestion there if they did. In the event of a sudden breakdown or sudden glut of traffic, the break of gauge was of vital importance. Frankly, he did not see why legislation was required. What was required was a policy, and if such a policy were established and the Government strong enough to carry it out, it would pay the Government over and over again to be very generous in the case of a light railway that lost its traffic. It was a policy which was wanted, and not legislation. To the speaker this was King Charles's head. Why was there not a policy? Because India would not allow railway men to manage railway business. Why was a narrow-gauge railway made here and a narrow-gauge railway there? Because the Finance Department said that it would cost an extra two lakhs or three lakhs, and that they had to balance the Budget. As long as that attitude was accepted he saw no hope for a policy. The essence of the question was that this was a matter which railway men

understood and ought to understand; it was not a matter which financial people understood, and the railway men must be trusted to do it. If the matter were put to the Railway Board, and they were told to present a policy, which it was their business to find, he was sure that they would go further and say that India was *qua* railways a single entity. It did not connect with railways anywhere else in the world. On the other hand, uninterrupted communication throughout India itself was vital. The men who came home from India came home usually to England, probably the country least desirable from this point of view, to have its railways studied. He was sure that the Railway Board could profit by the experience of the people of Australia, who were face to face with the same problem. He had not seen the report made on the complicated problem of the gauge in Australia. But he was certain that in the long run—and not the very long run—it would pay abundantly to have a policy, and that policy ought to be threshed out on the understanding that it was to be a permanent and continuous policy and not interrupted by financial opportunism which had been mainly responsible for the confusion. If Mr. Royal-Dawson could revise his map, it would do more for the cause he had at heart even than his very interesting paper.

A New Type Roller Bearing for Railway Axles

JUST before closing for press we have received some details of a taper roller bearing manufactured by British Bock Bearings Ltd., which is of a somewhat novel design. We give below a few details regarding this bearing, and in a future issue we hope to give fuller information regarding experience with this new design.

From the illustration it will be seen that the roller itself is slightly tapered, and is, therefore, adjustable. Because of the taper, it follows that it is necessary to provide a means for taking up the thrust, and it will be seen that this is carried out in a very business-like manner. The end of the boiler itself is spherical and makes a point contact with a portion of the housing upon which the rollers rotate.

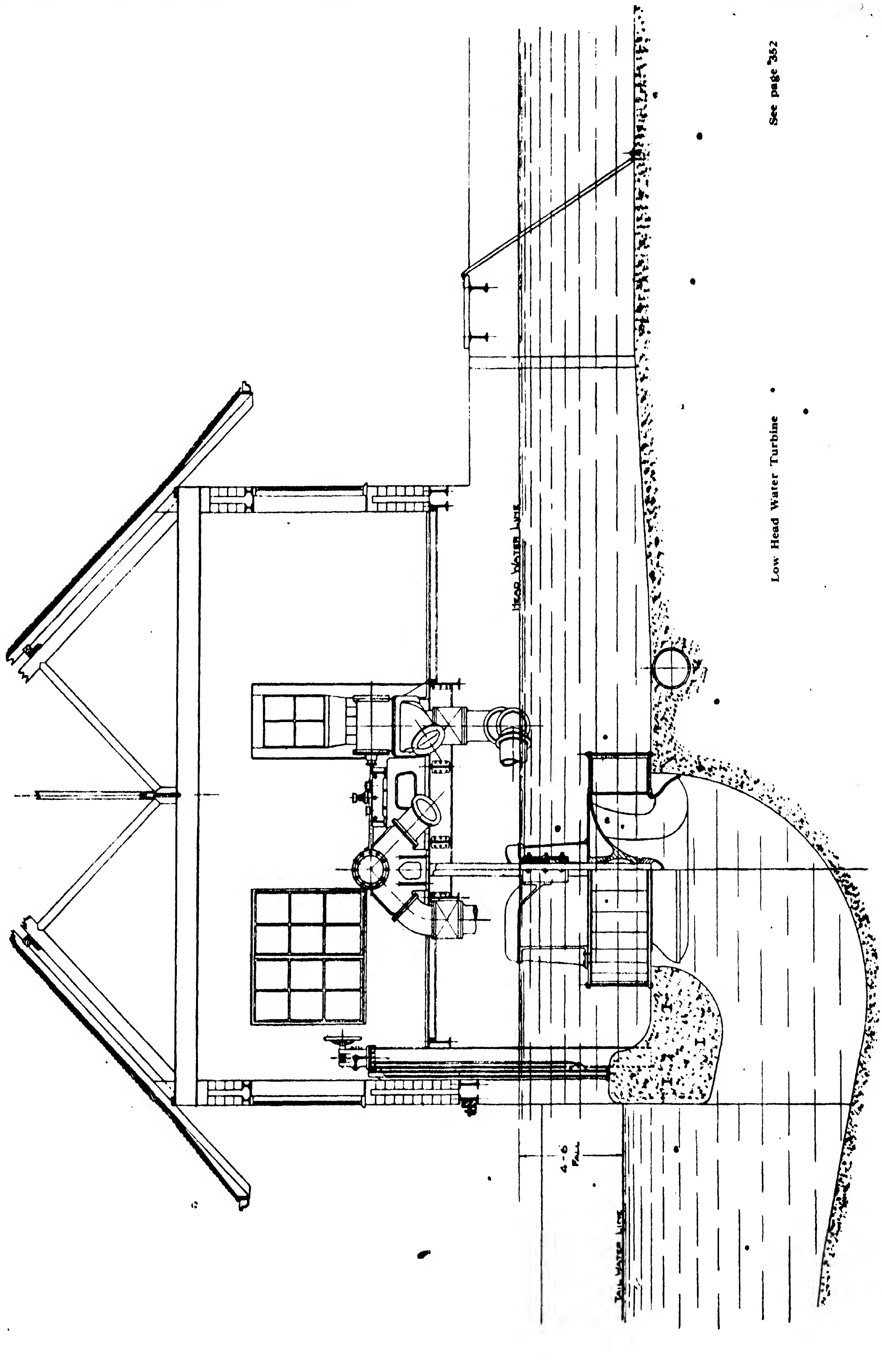
The principal claim, however, at this point is the fact that motion on the contact is a pure rolling action, and, therefore, friction is reduced to a minimum.

We understand that the company claim that this design of bearing will operate for a mileage of from 15,000 to 25,000 before any adjustment is required, and when the necessary adjustment is made, the bearing will carry on again indefinitely.

The details before us regarding actual performances refer to a number of different American companies who have fitted the Bock bearing.

One of their most representative installations is that of the Stanley Steam Car, which weighs 60,000 lb. without load. We understand that seven of these cars have been built, two of which have been shipped to South America, and have recently been put into service. The oldest car, however, has been in service five years, and is in operation on the White River Railroad, operating off the main line of the Vermont Central, running about twenty miles up into the mountains. Bock bearings were installed in this car in the spring of 1919, and we understand that the results have been entirely satisfactory.

We understand that a number of American companies have adopted the Bock design, and, in addition, several of the United States Arsenals are using this equipment for haulage and switching in their yards, and that in this latter case the Arsenals report that the Bock bearings are the only bearings that would stand up in this service, and, as a consequence, the Ordnance Department of the United States Army have specified Bock bearings on trucks used on rails.



Low Head Water Turbine

See page 352

The "Duplex-Mono"

A REMARKABLE NEW AUTOMATIC FLUE GAS ANALYSING MACHINE

THERE is now coming on the British market a remarkable new aid to fuel economy, the "Duplex Mono" automatic gas analysing machine, the invention of Messrs. The Svenska Aktiebolaget "Mono," of Stockholm, Sweden, represented in Great Britain by Messrs. Power House Components, Albion Chambers, King Street, Nottingham.

The machine gives a continuous record of the percentage of CO_2 and also of CO, and unburnt gases on the same chart. The importance of this achievement will be realised by a short consideration of the basic principles of flue gas analysis.

Air consists roughly of 79% nitrogen and 21% oxygen by volume, and assuming for the moment that coal was pure carbon, under perfect conditions of combustion, the air after combustion, that is the flue gases, would consist of 21% CO_2 (carbon dioxide) and 79% nitrogen. If now we analyse the flue gases and find less than 21% CO_2, it indicates at once that something is wrong with the combustion, and there is either excess or deficiency of air. With excess air the percentage of CO_2 is lower, and free oxygen is present, whilst if there is not sufficient air, only part of the carbon is burnt to CO_2 and the rest forms CO (carbon monoxide), so that there is again less than 21% CO_2 and free CO present.

Coming now to practical conditions, since coal, as a typical fuel, may contain anything from 50-94% of carbon, it is obvious that it is not possible to get 21% CO_2, even if only because the hydrogen present burns to water and does not give CO_2. Also it is impossible to burn coal with the theoretical amount of air, and some excess must be used, whilst leakage of brickwork is unavoidable. For these reasons, therefore, the theoretical figure in practice for anthracite, coke, and other fuels high in carbon, is about 19½% CO_2, and for ordinary semi-bituminous steam coals about 17%.

Losses by Excess Air

Dealing first with the losses caused by excess air, Fig. 1 shows the calculated percentage loss in the coal bill for each corresponding percentage of CO_2 in the flue gases, and from this point of view only, the higher the percentage of CO_2 in the flue gases the greater is the fuel economy. It is, however, a serious and fundamental mistake to pay attention only to the CO_2 figures, and to ignore the losses due to CO and other products of incomplete combustion. Thus, in Fig. 1, starting at, say 6% CO_2 and 33% theoretical loss, the curve—taking into account CO_2 only—gradually falls to 11½% theoretical loss at 20% CO_2. But as the amount of excess air diminishes there is a tendency for CO and unburnt products to appear, even though oxygen is in slight excess. In Fig. 2 typical curves are illustrated. At 14% CO_2 there is a theoretical loss of 15½% in the coal bill. If now we go past 14% CO_2, we get a further saving due to less excess air, but the beginning of an enormous loss due to CO and other unburnt products, since 1 lb. of carbon burns to CO_2 with the evolution of 14,500 B.Th.U., and if only burnt to CO, the evolution of heat is 4,400 B.Th.U. Thus, if we push the percentage of CO_2 to 15, the nett result would be a theoretical loss of 22% in the coal bill, and an actual practical loss of 6½% as compared with 14% CO_2, *i.e.* a gain of 1% due to increasing the CO_2, and a loss of 7½% due to CO. In other words, a low figure of 6% CO_2, with a theoretical loss of 33% of the coal bill, is just as efficient as 17% CO_2, because at this high figure the large amount of CO results also in a nett loss of 33%. The point C in Fig. 2, in this case 14% CO_2, no CO, and 15½% loss in the coal bill, is the *critical point of combustion*, at which the maximum efficiency is being obtained.

The ordinary CO_2 recorder only gives CO_2, and there has hitherto been no method of determining CO continuously along with CO. The enormous value of the "Duplex-Mono" is that for the first time it is possible to work at the "critical point of combustion," and thus obtain the maximum efficiency.

The machine is illustrated in Figs. 4 and 5.* It is impossible to describe it in detail in an article of any reasonable length, but the general principle is as follows:—A sample of flue gas is taken at the rapid rate of 30 times per hour, and

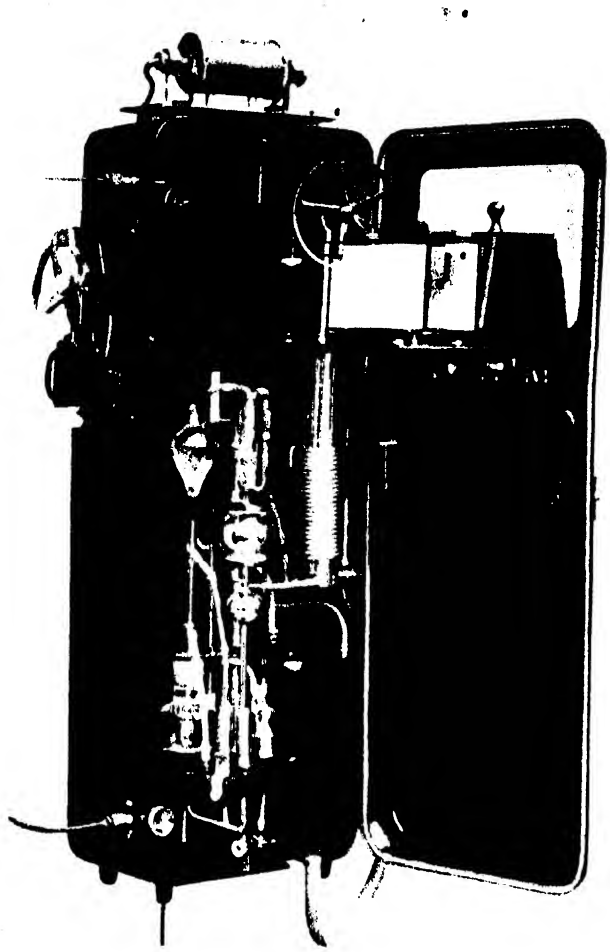


Fig. 4

each time 100 cc. is filtered and measured in the machine. Every alternate sample is then passed through 20% caustic potash solution in the iron vessel in the bottom right-hand corner of the machine, and the reduction in volume is measured in a floating bell above. That is to say, if the final volume is 90 cc., a reduction of 10 cc. due to CO_2 absorption, then the floating bell only rises to a mark corresponding to 90 cc. capacity. As the bell rises it actuates a pen, as seen, attached to a fine chain round a wheel, the pen travelling downwards over a ruled chart actuated by a 24-hour clock. In this respect the machine is an ordinary CO_2 recorder, except that it has the great advantage of using mercury as the moving liquid in the bulbs and tubes. The unique part of the machine is, however, that every alternate sample, instead of being sent direct to the caustic potash solution for analysis, is, by means of a highly ingenious automatic 3-way switch, shown outside the left of the machine (Fig. 5), turned in another direction, in which it has first to pass through a hard glass tube furnace containing copper oxide heated by an electric current.

This furnace is shown on the top of the machine, and in passing through all the CO is burnt to CO_2 by the hot copper oxide. Consequently, if the gas contains CO, there will now be more CO_2 in it, consisting of the original 10% CO_2 plus an extra amount due to the combustion of CO. The gas is then passed as usual to the caustic potash, and if, for example, 12% CO_2 is found, this extra 2% is due to CO. If no CO is present, the figure will be 10% as before. That is to say, the first sample of gas goes direct to the potash, the second through the electric furnace, and then to the potash, the third direct to the potash, and so on alternately, at the rate of 30 analyses per hour, 15 CO_2 only and 15 mixed gases. The rate of analysis is so quick that in practice this method of alternate analysis is just as accurate as analysing the two samples simultaneously.

Typical charts are shown in Figs. 6 and 7. Fig. 6 shows an ordinary boiler furnace not controlled by the "Duplex Mono." In the first place the total CO_2 figure fluctuates considerably, but averages about 8½-9%, being considerably above the average in this respect. At the points (B) and (C) on the left, there is an enormous difference between the alternate records, being often 10-11% on CO_2 only, and rising to higher than 15% for CO_2 + CO, indicating a high figure for CO. Fig. 7 shows an ideal practical chart working under control by the "Duplex Mono." There is practically no CO at all the whole time, except a small amount at the middle point (C). In working, therefore, with the "Duplex Mono," the correct method is first to concentrate on having no CO, that is, no difference in the alternate CO_2 figures. When this is attained, the percentage of CO_2 is raised gradually, say to 12-14%, but

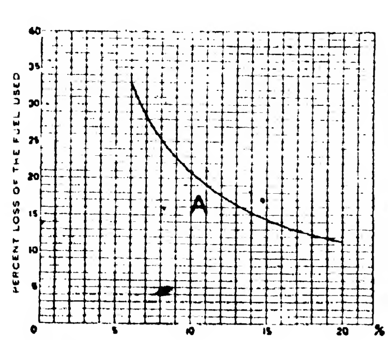


Fig 1.
Percentage of CO_2

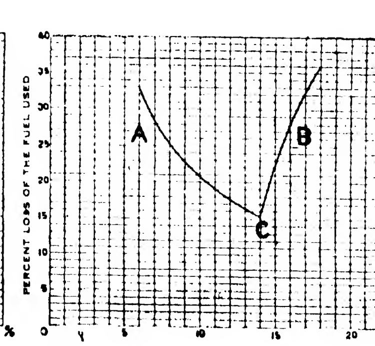


Fig. 2

stopping immediately there is any CO.

The machine is of the very finest workmanship throughout, and is worked by water pressure, at not less than 12 lb. per square inch, of compressed air. The whole of the mechanism can be turned out on a swivel for examination, whilst the machine goes on working, as in Fig. 5. It is recommended that the machine be erected in the firehole, in full view of the firemen. The iron door is dust-tight, having a rubber lining, as seen in Fig. 4, which makes a tight joint with the thin iron casing. The iron jug on the right is for charging with caustic potash solution, which lasts about a month, depending on the conditions. The chart and the ink reservoir last two months, and the clock requires winding up every seven days. Finally, the machine although apparently very complicated works extremely well. One of the reasons of this is the excellent design of the pen mechanism, which is almost impossible to go wrong, and another is the fact that heavy mercury being used as the actuating liquid, means an enormous suction is obtained, so that the flue gases can be filtered through tightly packed cotton wool filters and conveyed through capillary copper pipes without any fear of choking.

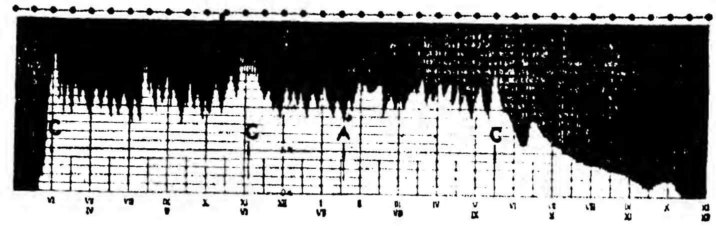


Fig. 7

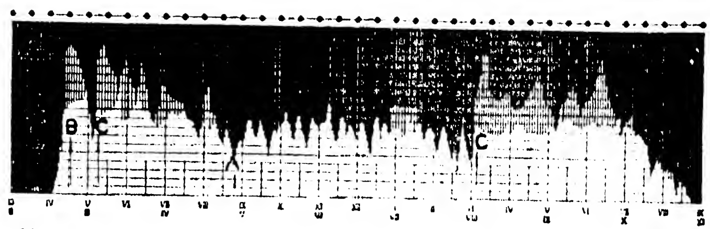


Fig. 6

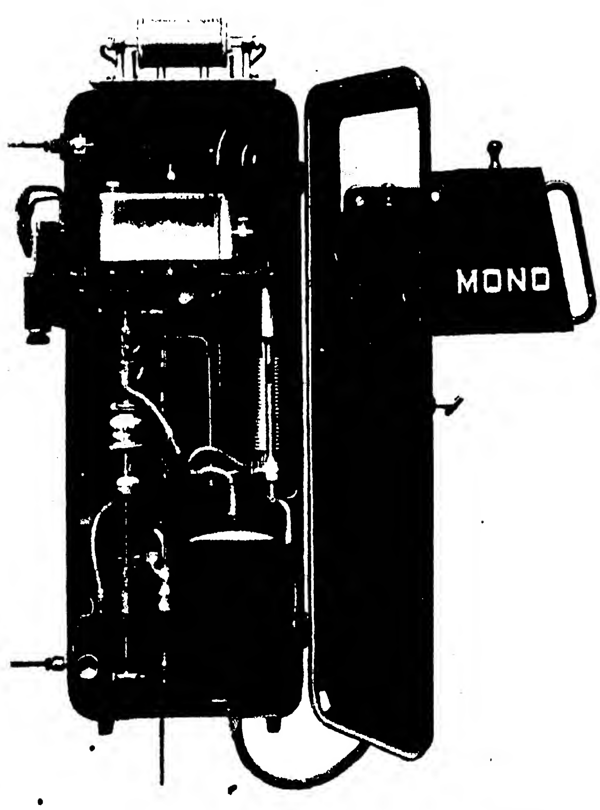


Fig. 5

Powdered Coal Successes

One of the first electric power stations in Great Britain to use powdered coal as fuel was a large municipal station in London. The installation was designed to serve a very large boiler, and the results have been so successful that additional plant to serve three more large boilers is to be put down. The main feature of this British installation is that it has enabled coal of a very poor quality to be burnt very economically. The coal is ground to a fine powder, which is then forced into the furnace, where, owing to the minute size of each particle, exceptionally complete combustion takes place. The main question for engineers is whether the advantages of burning powdered fuel compensate for the cost of reducing ordinary coal to the necessary fineness.

Fuel Saving in Modern Gas Producers

By W. B. CHAPMAN

The following article is taken from a paper read by Mr. Chapman before the American Society of Mechanical Engineers, and is of particular interest in showing the development in mechanically operated producers, and the saving effected by adopting mechanically operated methods.

THERE are about 10,000 gas producers in the United States. With the exception of the modern mechanical producer, most of these are "sick" and badly in need of a "gas doctor," and the furnaces they supply are in an equally bad way.

The producers in use are divided approximately as follows:—6,500 in the steel and allied industries; 1,500 in the glass industries; 500 in chemical industries; and 1,500 in miscellaneous industries. Under "miscellaneous" are included the ceramic industries, lime burning and about 200 gas producers used for power. The gas producer for power purposes has never been much of a success—except for small units using anthracite coal.

Engineers have given much attention to the engine room, some to the boiler room, a little to industrial furnaces, and least of all the making of raw producer gas. Hence the backward condition of the gas house.

No definite data has been compiled by the Government on the amount of coal used in gas producers, but with the assistance of such figures as are available it is estimated roughly that in the steel industries about 14,000,000 tons of bituminous coal are transformed annually into raw producer gas for use, and in the glass industries about 2,500,000 tons, and about the same amount in the various other industries.

In the steel industries approximately the same amount of coal is used for making gas to heat furnaces as for making steam. In glass making three-fourths of all the fuel is used in gas producers. But whatever producer gas is used it is apt to be the most backward part of the business. A given amount of time and money, if spent on improving conditions in the gas house, will usually bring larger returns than in any other department. In most industries requiring large heating operations, more trouble arises in that department than in any other part of the business.

Much progress has been made in the past 25 years in gas producer construction. It started with the excellent work of W. B. Hughes. Progress in furnace construction, however, has lagged. The chief incentive to improvement of both producer and furnace has been high priced labour, and the few advances made in furnace construction have been confined mostly to certain labour-saving features. Now the situation has changed; fuel saving has been put on a par with labour-saving, and interest is being noted all along the line.

The Producer Gas Process

In making producer gas there are three steps or operations: (1) Feeding the fuel; (2) agitating the fire; and (3) removing the ashes. Progress in producer construction has centered on various ways of performing these three operations automatically.

Automatic coal feeding, if continuous and uniform, will increase the B.Th.U. in the glass about 10 per cent., and will improve its uniformity to such an extent that it can be burned in the furnace with a 10 per cent. improvement in economy. However, the labour-saving due to automatic feeding is slight, and should not be confused with the labour saved by the use of coal-handling equipment and overhead bins, always a good investment for installations of more than one producer.

Automatic agitation, if suited to the kind of coal used, will increase the B.Th.U. from 10 to 20 per cent. (depending largely upon the zeal and skill with which it was formerly hand-poked) and the uniformity thus obtained will cause a corresponding saving in utilising the gas in the furnace. The combined effect of automatic feeding and automatic agitation usually makes possible a saving of 25 per cent. of the fuel required for a given operation.

Automatic ash removal is of two kinds, intermittent and continuous discharge. The intermittent type removes the ashes once or twice in 24 hours. It is open to the objection that during the ash-removal period the fire is badly disorganised, and a poor quality of gas is made for possibly half an hour. The continuous type of ash-removal is entirely free from this objection. In Europe the continuous type is much in favour, although but few have been installed in America.

The saving caused by mechanical ash removal depends largely upon the kind of device used. If the ashes are removed intermittently, and if no effective agitation accompanies the ash removal, the saving will be limited to the two or three hours' time required daily for the ashmen to shovel the ashes out by hand. If, on the other hand, the ash removal is continuous, and is accompanied by suitable agitation of the entire ash bed and lower portion of the fire bed, there will be a considerable saving to the labour required both for manipulating the fire and for cleaning clinkers off the walls. Moreover, the continuous type of ash removal, accompanied by ash agitation, will increase the capacity of the producer about 50 per cent., and will save some fuel on account of the improvement in the quality and uniformity of the gas. Unfortunately the continuous type of ash remover, combined with effective agitation, is little known in this country, although it is the common type in use throughout Europe.

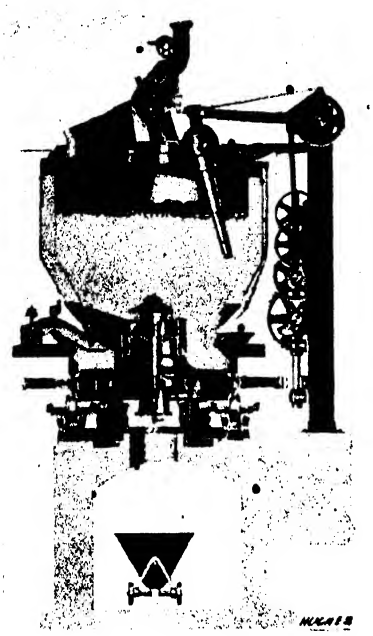


Fig. 1. Hughes Producer

Types of Producers

Bearing in mind the foregoing three steps in making producer gas, let us now consider the types of producers in most common use in America—the Hughes, the R. D. Wood, the Morgan, and the Chapman. Each is an excellent machine.

Hughes producer. To Mr. Hughes, then chief engineer of the Pencoyd Iron Works, is accorded the credit for having installed at that plant in 1897 the first successful mechanical producer in America. This machine is still in operation. As will be seen from Fig. 1, the chief feature consists in a vertical water-cooled finger hinged to the stationary top of the producer, and made to oscillate between the centre and the wall while the body of the producer and its contents revolve underneath. Thus, in time the entire contents of the producer are stirred. The speed of this producer was originally one revolution in 20 minutes, but every few years it has been increased, until now the walls make one revolution in 8 minutes, with considerable increase in capacity.

Since the installation of the first Hughes producer, an automatic ash-removing device has been added. It consists in a stationary bar arranged to sweep the ashes from a revolving grate. The bar is inserted once or twice every 24 hours for a short period and then removed. No attempt is made to use the device for agitating the lower portion of the fire bed. Recently an automatic feed has been added in fact two automatic feeds—thus making the producer completely mechanical. The double feed gives unusually good coal distribution. This is the oldest producer on the market, and there are over 900 in operation - more than any other mechanical producer.

The Wood producer (Fig. 2) is somewhat like the Hughes, in that it uses the vertical-stirring-arm principle. There are two vertical arms, one near the centre, and the other near the wall. These stirring-arms are bent as shown in the illustration, but instead of oscillating from centre to side they revolve around their vertical axes. The walls of the producer revolve, and thus the fire bed is carried past the stirring device. The coal is fed from a rotating drum located eccentrically. As a revolving fire bed comes under the feeding device, fresh fuel is supplied to it. The speed of the producer is one revolution in 30 minutes. A steam-turbine blower is supplied, in addition to the ordinary steam-jet blower. The turbine has an extra large capacity, operates quietly, and usually gives results that are more uniform than a steam-jet blower.

The ash is removed by a blade or plow attached to the lower edge of the revolving wall, and extending down into the ash bed. The blade takes out ashes at a fixed rate, which is somewhat faster than they are made, and therefore it cannot be operated continuously, although nearly so. Scoops are attached to the skirt of the revolving wall for carrying the ashes around to a suitable point for final discharge. The capacity of this producer is unusually large, owing to the fact that there are two stirring arms in place of one, and the removal of the ash is nearly continuous. Moreover, the diameter of the Wood producer is 10 ft. 6 in., instead of the usual 10 ft. This producer is particularly popular among glass manufacturers, and some remarkable records have been secured with it.

In a producer having vertical stirring fingers, it is highly desirable to keep the top and bottom of the fire bed always at the same level, so that the stirring fingers will always project the right distance into the fire bed for best results. If these fingers should reach too near the ashes, the air blast would break through into the recess or gap left in their wake and spoil the gas. A continuous, or at least semi-continuous, ash removal would thus seem to be necessary in order to keep approximately the same amount of ashes in the fire bed all the time, and the same amount of ashes continuously in the producer. Producers with long vertical stirring fingers are difficult to operate with a thin fire bed, or at less than two-thirds of full capacity.

The Morgan Producer

The Morgan producer (Fig. 3), like the Hughes, is 10 ft. inside diameter, and has about the same capacity. Also, like the Hughes, it is very popular in the steel trade. However, it differs radically in both the method of agitation and in the ash removal. Instead of vertical arms projecting deep into the fire bed, a horizontal arm which rides on the surface is used, it being claimed that surface agitation is quite sufficient, and anything more is detrimental. The writer's experience would seem to prove that surface agitation is hardly adequate when caking coals are used. Nevertheless, some very excellent results have been obtained. As will be seen from the illustration, the agitator is in the form of a swinging U-tube, with the ends hinged to the stationary top of the producer. The walls and the ash-pan of the producer revolve and carry the fire bed around with them. The speed has recently been

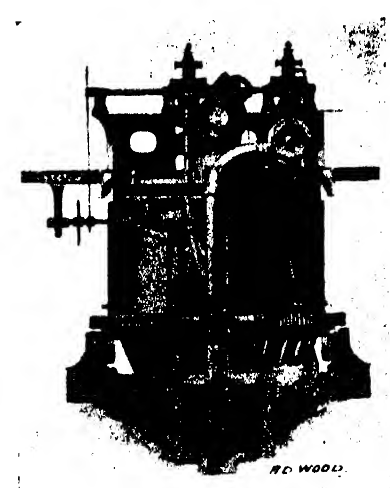


Fig. 2. R. D. Wood Producer

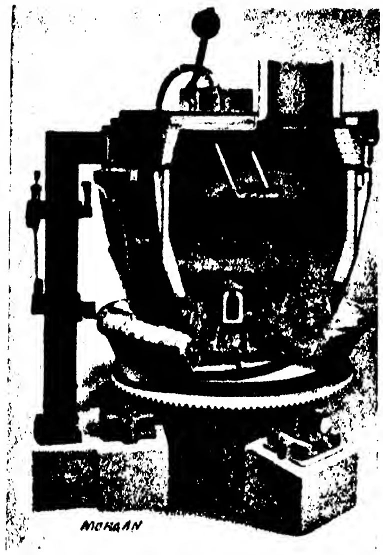


Fig. 3. Morgan Producer

increased to one revolution in twelve minutes.

The ash is removed by a spiral arm lying on the bottom of the ashpan. Ordinarily, the arm revolves with the pan, so that no ashes are removed. From one to three times every 24 hours the outer end of the spiral arm is engaged and held fast, thus producing relative motion between the arm and the pan, and causing the ashes to flow out rapidly. An ingenious device provides for the automatic release of the ash arm when the producer has made a full revolution. The ashes obtained in this way are exceptionally free from carbon. After the ashes are taken out, the fire bed is "broken down" by hand poking, and drops from six inches to a foot. The producer is exceptionally well built.

In all gas producers that do not provide for continuous removal of the ash, there is a definite cycle of operation, extending from one ash-removing period to the next. This is usually a 24-hour cycle, but in some cases it is 12 or even 8-hour, and in the case of the Wood producer it is semi-continuous. At the beginning of the cycle (immediately after the ashes have been removed), the fire bed, though not changed in thickness, is located much lower down in the producer than at the end. This difference in height of the location of the fire bed in the producer from the beginning to the end of the cycle is usually about 2 ft. if the ashes are removed but once in 24 hours, but it is correspondingly less when the ashes are removed more frequently. It is therefore apparent that if a producer is to be agitated uniformly, it should be provided either with approximately continuous ash removal or with an agitator which automatically varies in height according to the varying height of the fire bed.

The Chapman producer (Fig. 4) is the only gas producer sold in parts. The agitator alone may be installed on any stationary producer, or the agitator in combination with the automatic feed may be installed on old or new stationary producers, or again, a completely mechanical producer including automatic feed agitator and ash remover may be obtained. The agitator, as will be seen from the illustration, is in the form of a rake with water-cooled teeth. The rake revolves once in 7 minutes, and thus every portion of the fire is passed over every $3\frac{1}{2}$ minutes, which is more than twice as frequent as in any other producer. In most producers agitation depends upon the speed of the walls, which are rather cumbersome to operate rapidly.

The Agitator

The agitator is driven by a patent driving head having two long spiral flanges upon which the agitator automatically "screws up" as the fire bed grows higher, and "unscrews" when the height of the fire bed drops. These spiral flanges are in sliding contact with two revolving lugs which project inwardly from the hub of the driving wheel. As fresh coal is put on the fire, it tends to bury the agitator beneath it. This makes the agitator turn harder through the fire bed, and immediately, as the torque is increased, the driving head screws up to where the forces are again in balance. If the agitator strikes a large clinker fast to the wall, it screws up over it and drops down on the other side, thus avoiding any undue strain on the machinery. The action is a little like that of the Yankee screw driver.

The cross-arm of the agitator operates a few inches below the surface of the fire bed, and the fingers project down 8 in. further. This makes the depth of the agitation about mid-way between the surface agitation of the Morgan and the deep agitation of the Hughes and Wood. As the fingers project forward, the cross-arm immediately fills in the gaps in their wake. The out-stroking effect of the cross-arm tends to pack the fuel against the wall, which helps to prevent blowholes and clinkers.

The automatic feed drops the coal evenly over all parts of the fire bed simultaneously, and thus differs from the other mechanical producers in that it does not require a revolving fire bed to spread the coal. The object is to produce slightly better gas-making conditions than when the fuel is dropped only in one corner or sector of the producer at a time.

The ash-removing device operates continuously. It consists in a slowly revolving beam extending across the producer through the ashpan, and driven by a gear ring which encircles the producer just above the pan, the speed being adjustable to synchronize with the rate the ashes are being made. The speed of the gear ring is adjustable from a revolution an hour to one in ten hours. After the ashes have been forced out by the beam into the outer portion of the ashpan, they are picked up by scoops attached to the gear ring and carried to the point of discharge.

The Chapman producer makes use of the European idea of agitating the fire bed from beneath. The ash beam is provided with fingers which project upward and impart motion both to the ashes through which they move and the fire bed resting on the ashes. This is to help in preventing blowholes and clinkers and to increase the capacity.

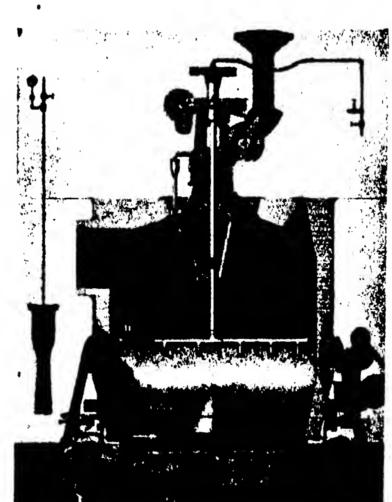


Fig. 4. Chapman Producer

The size of this producer is 11 ft. inside diameter—the largest made and the capacity is increased accordingly.

Savings with Mechanical Producers

With the usual more or less unskilled and indifferent handling any of the four American mechanical producers can make a gas averaging 150 B.Th.U. (low values) instead of the customary 125 B.Th. U. obtained in hand-poked producers if operated with zeal. With skilled handling the best mechanical producers will average 160 to 175 B.Th.U., provided the coal is fair and the rate of gasification does not exceed 25 or 30 lb. per square foot per hour, which is fully twice the capacity of hand-operated producers.

A Duff producer operated originally at 10 tons a day and making gas having 125 B.Th.U. was fitted with a Chapman agitator and automatic feed, and at 36 tons a day, gave an average of 163 B.Th.U. Similarly, a Von Kerpley producer, the most popular mechanical type in Europe, gasifying 20 lb. per square foot per hour, making about 135 B.Th.U. gas, was equipped with Chapman agitator and automatic feed, and changed to 34 lb. gasified per square foot per hour and 178 B.Th.U. This was maintained without difficulty, and without any hand poking.

The best modern producers properly operated will usually save about 25 per cent. of the coal, and at least an equal amount of labour. These savings should amount to the total cost of the installation in from one to four years. The Chapman agitator with automatic feed, when installed on old hand operated producers, will usually save its cost in the first year of operation.

The temperature in a gas producer is highest at the bottom of the fire, and the thicker the fire the cooler the top. The temperature at the bottom should be as high as the fuel will stand without running too much risk of melting the ash. The melting point of the ash in all good Pittsburg gas coals is well above 2,500 deg. F., and the melting point of the ash in Illinois coals is about 300 deg. lower. The temperature at the top of the fire bed should be as low as will permit the gas to be conducted to the place of use without forming objectionable tar deposits, and also as low as possible without making the top too sticky and difficult to blow through. Usually a "top temperature" of 1,000 to 1,100 deg. F. is about right, but if the gas is to pass through a water-cooled reversing valve located some distance away, 1,200 deg. would be better. A "hot top" destroys some of the richest gases, and thus wastes fuel. More fuel is wasted in a producer from running with a hot top, *i.e.*, over 1,300 deg., than from any other cause.

A considerable saving of coal can be brought about by using suitable accessories in the gas house. The most important of these is a pressure regulator, which, when the pressure in the gas main falls, blows the producer harder, and makes more gas, and *vice versa*. A temperature recorder is also of great assistance. A few additional devices are needed if one is to obtain the highest efficiency in daily operation.

Boiler Flue Cleaning by Suction

THE use of a partial vacuum has in recent years been adapted for several different industrial purposes, such as the cleaning of buildings, railway carriages, etc., and also for the conveying of grain, ash and coal. One of the most recent uses found for this system is the cleaning of steam boiler flues, and the great convenience of such a system is obvious.

Everyone is familiar with the dirtiness and general inconvenience at the time of flue cleaning, and the wonder is that the suction or vacuum system has not been adapted sooner.

We propose here only to give a brief description of the plant designed by The British Vacuum Cleaner Co. Ltd. (Booth's patents), and to illustrate the principal portion of the apparatus used.

Advantages

This plant for flue and economiser cleaning has great advantages over the "sack and barrow" method. There is a great saving of time and labour. Only one man is required to operate a plant having a removal capacity of up to 3 tons per hour. The dust is conveyed by suction direct from the flues to the dust container, from which it is discharged in a damp condition, so that blowing about of the dust does not take place. Where, owing to the type of boiler or setting, it is necessary for a man to enter the flue, he is operating under sanitary and healthy conditions, and labour difficulties are therefore lessened.

The general lay-out of the plant is as follows :—

An air exhauster of the positive reciprocating or rotary type, belt, chain or gear driven by electric motor or other means.

An interceptor or air washer which prevents any fine dust reaching the exhauster.

A main dust container for receiving the flue dust, which is mounted on a suitable staging so that it may discharge into a railway wagon or cart. A suitable size for a plant of 30 cwt. per hour removal capacity is 15 ft. high by 5 ft. diameter, holding 108 cubic feet of de-aerated dust, equal to 252 cubic feet of free dust approximately.

These are connected by W.I. piping, and a vacuum relief valve is fitted in circuit coming into operation at maximum required vacuum.

From the dust container a W.I. dust-air main is run to the boilers, and terminates in one of the following ways :—

Method of Collecting

1. Hose connection fittings to one of which is attached a length of flexible hose fitted with the firm's special aerator hose nozzle when cleaning is in hand. Into this nozzle the dust is raked, or alternatively the nozzle is pushed into the dust. The dust is then at once carried away by suction through the pipe-line to the container, which is emptied at intervals on to a dump or into wagons, etc.

2. Where it is possible to arrange it, the dust main is connected to dust hoppers under the boilers, etc., through patent aerator valves. It is then only necessary to open these valves in turn, and the dust is automatically conveyed through the dust main to the dust container.

Branch Pipes

3. Branch pipes fitted inside the boiler, these pipes being fitted with special aerator dust suction nozzles.

In a later issue we will deal fully with the suction or vacuum system, showing its utility in the boiler house, and its different applications.

Exhauster House

THE DEVELOPMENT OF LIGNITE (Brown Coal)

At a meeting held recently of the Dominions and Colonies and Indian Sections of the Royal Society of Arts, a paper was read by Professor W. A. Bone on "Brown Coals and Lignite." As is well-known, lignite or brown coal is a quality of fuel intermediate in quality between peat and coal. That is to say, it is a much older stage than peat in the complete conversion of the original vegetable matter into pure carbon, but not approaching that of ordinary semi-bituminous coal, and far removed from anthracite. Lignite itself differs greatly in properties, varying from a loose brown fibrous material (earthy lignite), little removed from peat, to a hard, brownish black solid, approaching coal. It is, however, in averages much inferior to coal, the analysis being about 5,500—7,500 B.Th.U. per lb., as against say 11,500—13,500 for coal, and it generally contains a large percentage of moisture. Against this, however, is the fact that it can be "mined' at the surface at a fraction of the cost of coal.

The "Nesdrum" Water-Tube Boiler

The "Nesdrum" water-tube boiler, manufactured by Messrs. Richardson, Westgarth & Co. Ltd., is making headway in Great Britain, and several minor improvements in the design have recently been introduced. The "Nesdrum" boiler is of the straight tube variety, but of rather unusual design, consisting of a series of nests or "bunches" of straight tubes fixed to small, spherical-ended, cylindrical vessels or drums at the top and bottom, in two rows, placed in the front side by side inclined at an angle over the furnaces, together with one row of similar nests of tubes with small drums placed vertically at the back of the boiler, combined with a large horizontal steam drum extending the full width of the boiler at the top between the front and back sections of tubes.

The new improvements introduced into the design of the boiler are that straight nipple tubes are now used entirely for connecting the sections together, instead of the previous bent tubes, whilst the lower vessels or small drums are made deeper, so that, on removing the manhole covers, the nipple tubes, together with the main tubes, can easily be inspected without difficulty.

One of the features of this boiler is the absence of metal-to-metal joints and small hand hole fittings. The feed-water enters the headers of the rear nests of tubes, and passes down these to the rear bottom vessels or drums, the coldest water being therefore brought into contact with the coolest gases as they pass out of the boiler, this rear series of vertical tubes acting more as an economiser and a feed water heater, whilst any minute amounts of mud and scale-forming elements are also deposited at this stage. The circulation in the straight tubes of the front two rows of nests of tubes inclined over the furnaces is direct and rapid, whilst the superheater is situated behind these, under the main horizontal steam drum, and before the flames and hot gases reach the back row of nests of tubes.

Owing to the absence of flat surfaces, which need staying, the "Nesdrum" boiler is very suitable for working at the highest pressures, up to 500 lb. per square inch, and two boilers have recently been erected in Sweden with a working pressure of 350 lb. per square inch and 700 deg. F. steam temperature, whilst it is equally applicable to firing by all fuels, solid, liquid, and gaseous.

An installation of "Nesdrum" boilers on the latest lines, with chain grate stokers, superheaters, and cast-iron economisers, is now being erected in Warrington, consisting of four boilers of 16,000 lb. evaporation each, at 200 lb. working pressure, and many boilers are at work in different parts of Great Britain, the largest installation being nineteen boilers at Cargo Fleet Iron Works, Middlesbrough.

The Ramsay Rotary Condenser

A novel method of condensing the exhaust of a steam engine

WE reproduce a sectional view of this somewhat novel method of condensing the exhaust of of steam engines and turbines. The principal claim made for this design is that it only uses one pound of water for one pound of steam condensed, maintaining vacuum up to 29 inches. The following details are supplied by the makers, Messrs. Fullerton, Hodgart & Barclay Ltd., of Paisley.

The Ramsay condenser consists of a series of nests of tubes so arranged to form an annular ring, with a chamber at one end to form a receiver for steam to be condensed, and also a chamber at the other end to form a receiver for the condensed steam and air vapour.

Each of these chambers have a trunnion formed on them, which serves the double purpose of forming carriers, and also steam inlet and outlet for condensed steam and air vapour, the condensed steam and air vapour being withdrawn by means of an air pump. The whole is capable of being rotated, so that every tube is in turn immersed in a tank holding the condensing water, and rises out of the tank covered with a film of water.

Steam to be condensed enters through the trunnion at one end, passes through the end chamber or header to the inside of the tubes, where heat transmission takes place, the heat from the steam passing through the tubes and evaporating the film of water on the external surface.

The condensing water having been evaporated, the heat of evaporation will have been extracted from the steam contained in the inside of the tubes, which becomes condensed, thereby forming a vacuum. The condensed steam then passes along, and out of the tubes into header through the trunnion to the outlet pipe at the opposite end to that by which it entered.

To remove the vapour of evaporation and also produce a cooling effect on the tubes, a fan discharging cooling air into the annular space at centre of tube nests is required. This air passes out among the tubes to an outer casing, and by means of a pipe to the external air.

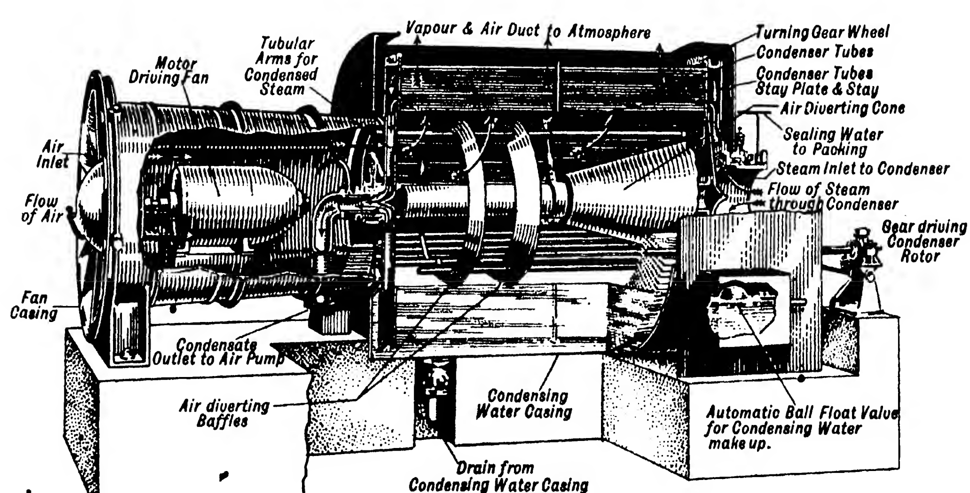
The tubes where a transfer of heat takes place are made of brass, copper, or other metal of good heat-conducting properties.

These tubes are carried by means of tube plates fixed to end chambers or headers, which headers have hollow trunnions concentric with the annular ring of tubes.

The trunnions are carried by means of pedestals which may sit on, or form part of the tank, the tank being filled with condensing water.

The headers are so divided up by means of vanes as to form the tubes into four or more nests, each nest in turn having the flow of steam shut off by means of directing pipes, which cause the steam to pass through tubes which have left the water in the tank, and are covered with a thin film of water only.

The trunnions are made air-tight by means of packing glands combined with a water seal.



"THE ENGINEER" SWAIN SC

Diagrammatic Section through Ramsay Rotary Condenser

Baffle plates are inserted between headers so as to cause cooling air to pass round about the tubes before reaching the outer casing.

A distance piece is placed between the headers so as to ensure that the tube plates are kept at their proper distance apart. This distance piece also acts as a conical guide, to deflect the air round about and among the tubes before reaching the outer casing.

Rotary motion is communicated to the tubes by means of a worm wheel, worm, and shaft. The shaft may be rotated by motor, belt, or rope drive.

Spur wheels and pinions may be used instead of worm wheel and worm, and may be applied in the same position, or at the periphery of the headers.

The flow of steam into and through the condenser, and also the air inlet and outlet, are shown by means of arrows on photo print.

The Efficiency of the Modern Chain Drive

In this article a detailed account is given of the chain drive, particularly of the specialities of the well-known firm of Messrs. Hans Renold Ltd. There is no question of the great saving in power that can be obtained by paying particular attention to the question of efficient transmission, and the writer points out that in the average case 10% of the power generated is to be saved by substituting belt drive by chain drive. The advantages of the chain drive are considered in detail, but at the same time the disadvantages are elaborated, so that the power user can give the matter full consideration in all its aspects.

ONE of the most neglected sources of power economy in the average industrial establishment is in the transmission of power. Very few power users, for example, are in a position to state the exact loss that takes place between the actual point of the generation of power and its application. It is generally an astonishing experience to determine, as the present writer has done many times, the total friction load of a factory, that is, the total horse power required to merely drive the shafting, gearing, and belting without doing any useful work at all. Thus it is quite common to find 10-15%, or even over 20%, of the power generated is swallowed up in this way, and at least 10% of the fuel bill can generally be saved by detailed attention alone to the transmission. It is the purpose of this article to deal particularly with the actual driving from the shafting to the machines, and the substantial economy that can generally be obtained by the utilisation of modern chain drives in preference to belt driving and the use of gearing, and also, in a lesser degree, to rope driving.

Factory driving is of two general kinds, positive and non-positive.

Positive, or rigid, methods of the transmission of power, such as spur wheels, bevel wheels, and helical gearing, are generally used when the distance between the shafts is very short. The efficiency of this method of transmission is very high, over 95%, provided always that the form of the teeth is designed and constructed with great accuracy, so that the driving motion will be equivalent to the rolling together without slipping or rubbing of cylinders or cones. In practice, however, it is very difficult to cut and erect such gears, and most factory drives of this nature, especially when not of recent date, are grossly inefficient, noisy, and give rise to excessive vibration. Of course, modern cut gearing is of quite a different character, but the ordinary type of positive drive can be said to be wasting anything from 10-25% of the power transmitted.

The non-positive, or non-rigid, type of drive, in which the distance between centres is long, and the exact speed ratio does not matter, as represented by the ordinary belt or rope drive, is, however, what may be termed the standard industrial drive. The rope drive, when carefully designed and erected, is very satisfactory, especially for long distances, and the average efficiency obtained is probably about 92½-95%, but it is not used to anything like the extent of the belt drive. Accordingly, therefore, this article—because of lack of space—will be concerned chiefly with the substitution of the belt drive by the chain drive. A belt is a flexible and more or less elastic band in which the friction necessary for the drive is obtained by the tension or pressure of the flat belt on the pulley. A belt drive must result in a loss of power for three principal reasons. In the first place the initial tension necessary for the drive causes extra friction in the shaft bearings, and secondly, the substance of the belt has to be bent continually and the internal friction overcome. Also, the belt "creeps" on the pulley, because it does not enter and leave the driving pulleys under the same tension, and, therefore, since it is more or less elastic, it changes its length, and slipping is the result. Many complications enter into the question of obtaining the best results from a belt drive.

In addition to correct design in the way of width of belt, material of the belt, diameter of pulleys, the distance between centres and the arc of contact, the efficiency depends on a proper tension and the correct co-efficient of friction. One of the great difficulties, however, is that the results obtained depend to a large extent on the atmosphere. The temperature and the amount of moisture, almost always varying,

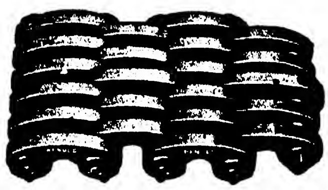


Fig. 3

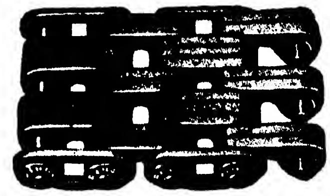


Fig. 4.

lter the length of the belt, the ension, and the co-efficient of friction, so that a considerable loss in fficiency cannot be avoided. In ractice also, in most cases, the ideal onditions as regards design are not ossible, and the proper care and ttention necessary to the best esults is not given. As a consequence the efficiency of the belt rive in practice may be anything rom, say, 80–92½%, and even under he very best conditions about 8% of the power is lost. Under average ormal conditions the figure is 8–12% oss, and in thousands of drives under ad conditions, particularly as regards attention, the loss is as much is 20%. The essential point is herefore, that in the average industrial establishment, say, 10% of the ower, that is 10% of the coal bill ised in the generation of power, is eing lost in the belt driving alone, and probably more in the spur and bevel wheel gearing.

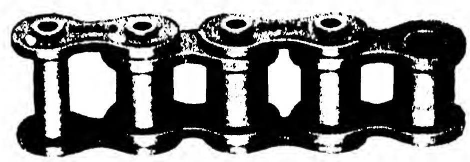


Fig. 1

Fig. 2

Most of this loss can be prevented by the use of the modern chain drive, which has also other advantages in the way of increased floor space available, better working conditions, and a more even and regular turning movement, combining, in fact, most of the good points of the belt and rope drive, and positive driving as well.

In order to get the latest information relating to chain drives, the writer made a special visit to the world-famous works of Messrs. Hans Renold Ltd., at Burnage, Manchester and takes the opportunity of thanking this firm for their very great courtesy in placing the whole of the facts at his disposal and showing him every detail of their factory. The wonderful and efficient organisation of the whole establishment will form ample material for some future article, and it will be sufficient to say that the firm of Hans Renold started in 1870 making bicycle chains, and employed one man and one boy. The present model works at Burnage, which were opened in 1908, employ about 1,500 people, and are engaged in supplying every description of driving chain to practically every country in the world.

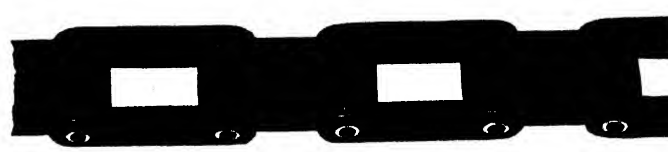
There are various general types of chain used for driving purposes.

The bush roller chain, as illustrated in Fig. 1, was invented by Mr. Hans Renold in 1879, and is a development of the old "bowl" chain, which consisted of a bowl or roller mounted on plain studs, and held between side plates. The bush roller chain has bearings composed of a pin and bush knuckle joint with a roller running on the outside of the bush to reduce the friction between the chain and the wheel when entering and leaving. It is also provided with shouldered studs to prevent the inner and outer plates from rubbing together when the chain is riveted up. This chain is provided with joints of two distinct types, acording to the conditions, either a bolt and nut, or a spring clip, the latter being particularly used for cycle and motor-cycle work.

The bush roller chain has a number of advantages for special purposes. Thus it is very light for the horsepower transmitted, and especially valuable for very long centres at high rates of speed, such as aeroplane and other aerial propellers, centrifugal pumps, hot saws, etc. When the life of the chain is of minor importance, the speed can be as high as 5,000–7,000 feet per minute. The bush roller chain is also used for the great majority of direct drives from lineshaft to machines, in the slower speeds between lineshafts, and in the majority of second reduction gears. It is particularly suitable for motor cars, motor wagons, and cycles, and has the further advantage of being very narrow for the power transmitted, which is valuable where the chain may run out of line, and it will gear on both sides, often a big advantage where jockey pulleys have to be used.

What is known as the extended pitch bush roller chain (Fig. 2) is a special variety of the ordinary bush roller chain, of simpler construction, intended for the transmission of less than 50 h.p. for comparatively long distances, and where large pinion wheels can be used.

The silent inverted tooth chain, as supplied by various well-known makers, such as Brampton, Coventry Chain Co., Morse, and Hans Renold, is the original invention of Mr. Hans Renold, having been patented in 1895. It consists, as seen in the illustrations (Figs. 3 and 4), of a series of flat steel links with working faces in the form of inverted teeth, hinged and held together by hard-



Block Chain

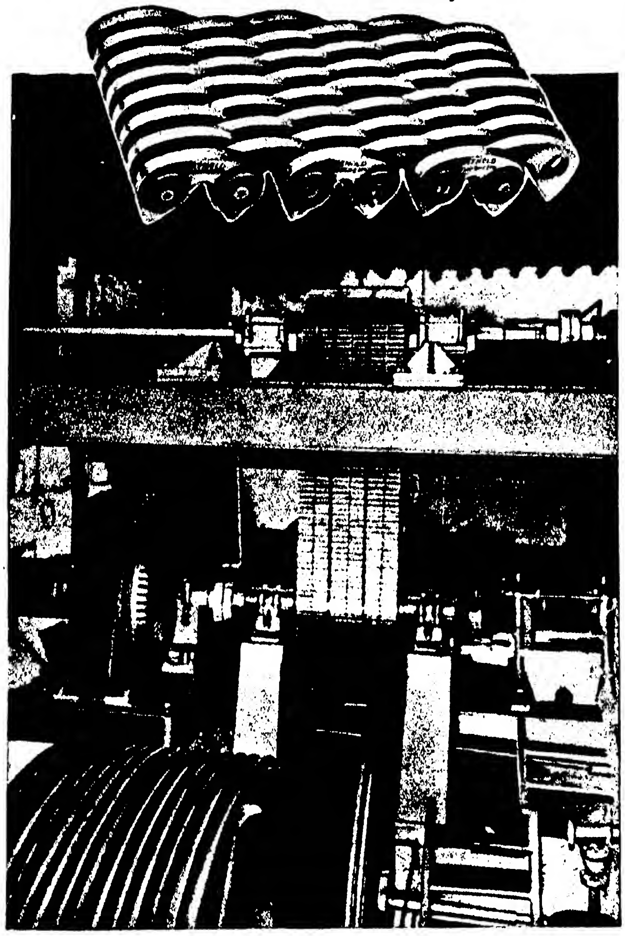


Fig. 7

ened steel studs and liners or other bearings.

The inverted tooth chain, whether with liner or segmental bush bearing, is essentially the type of chain for general factory driving purposes, as it gives noiseless and efficient running at the high speeds of motor driving. Thus a reasonable average working speed with a 19 tooth pinion or over is 1,400 feet per minute, and in general, with pinions of 19-30 teeth the speed varies from 1,600 feet per minute at, say $\frac{3}{8}$ in. pitch, down to 480 revolutions per minute at $1\frac{3}{4}$ in. pitch, transmitting up to 100 h.p. per strand. It can be constructed of almost any width, so that for even the largest horse-power the number of strands required is small. In fact, in the most extreme cases it is not necessary to use more than four strands, and drives up to 600 h.p. are commonly installed with three strands. Under special conditions, however, thousands of horse-power can be transmitted.

Fig. 9

Another advantage of the inverted tooth chain, as compared with the bush roller type, is that it gives much more even turning, a specially valuable point in cases like the driving of grinding machines and calendars for paper making, dyeing, etc.

The advantages of chain driving are as follows, considering more particularly the inverted type of chain as compared with the ordinary belt drive: -

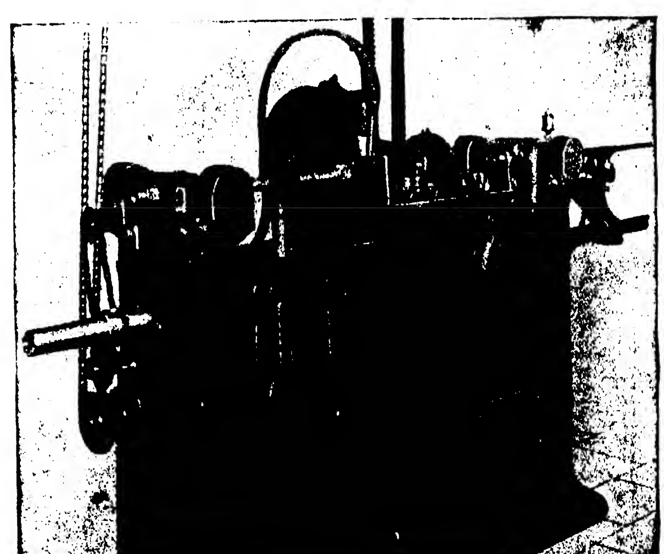


Fig. 10

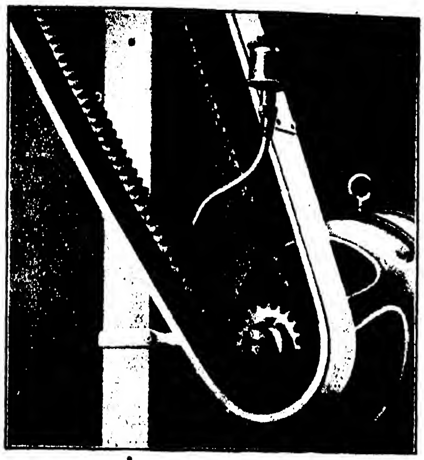
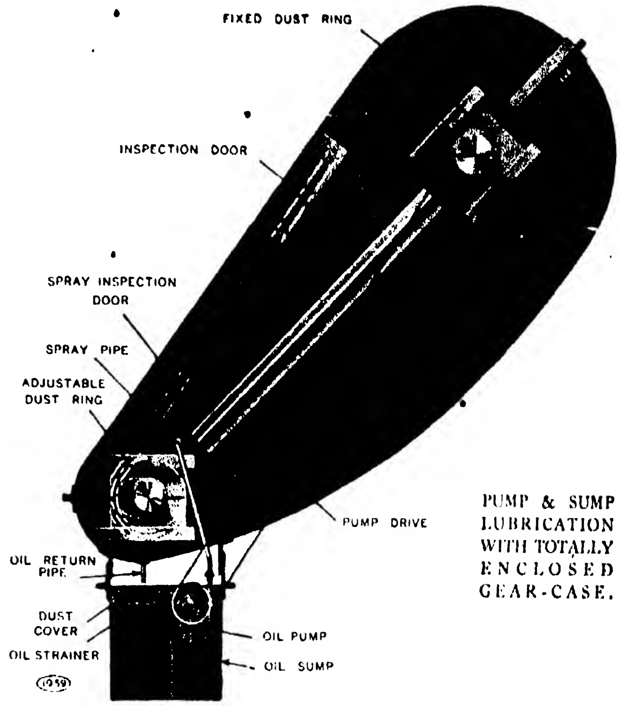


Fig. 14



PUMP & SUMP LUBRICATION WITH TOTALLY ENCLOSED GEAR-CASE.

Fig. 13

1. Efficiency.

The chief advantage of the chain drive is its much higher efficiency. Thus, under the best conditions, with enclosed forced lubrication, results as high as 99.5% can be obtained, and 98% is quite a common figure for ordinary commercial conditions with only moderate attention. That is to say, the substitution of a chain drive for a belt drive results in a saving of no less than 8-10% of the power. Further, this high efficiency is maintained throughout the life of the chain without difficulty, because as the chain wears, it mounts the wheel teeth and adapts itself to a greater, but still correct pitch circle.

2. Small Space of Drive.

The space required for the drive is extremely small, and infinitely superior in this respect to a belt or rope drive. In fact, a highly efficient drive can be obtained with the wheels almost touching, so that spur gearing can be replaced without difficulty. A good example of this is seen in Fig. 6, in which a "Renold" chain is transmitting 150 h.p. from a motor to 3-throw pumps at only 24 inch centres.

Another illustration of a heavy drive with a short centre is given in Fig. 7, which shows a chain drive transmitting 400 h.p. from a motor shaft running at 485 revolutions per minute to an overhead lineshaft at 180 revolutions. The drive consists of three strands of 1.75 in. inverted tooth chain, 7 ft. 2 in. centres, running in enclosed oil bath gear case, with the chain lubricated by force pump from the filter sump. In the photograph the gear case is removed to show the chain. The large grooved fly-wheel in the foreground was the former rope drive, and illustrates the great difference in the space.

Again, in Figs. 8 and 9, is shown a gear cutting machine, first belt driven with a 9 in. belt, which was then replaced with a 2¼ in. chain, resulting also in 40% additional production from the machine. In Fig. 9 the chain covers are removed to show the drives, overhead lineshaft to cutter spindle, and cutter spindle to dividing and transverse motion.

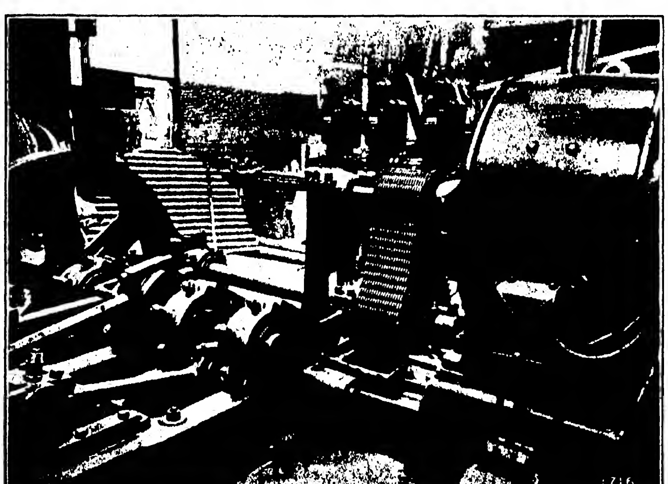


Fig. 6

3. Smoothness of Running.

The smoothness, regularity, and silence of the chain drive is extraordinary, and the value of these

advantages can only be realised by actual practical experience. This is due to the fact that the load is distributed over a large number of teeth, each tooth taking a small proportion, whilst also the pull comes on very gradually.

4. Positive Driving.

The drive is absolutely positive, and there is no slip, so that the power transmitted is always sure and definite, in addition, of course, to the high efficiency already mentioned.

Other advantages of the chain drive include much greater reliability, the breaking of a chain being practically an impossibility because of the large and definite factor of safety that can be given in the mechanical construction of a chain. Also there is an absence of electrical discharge (as with belts), heat and damp have no effect, the erection is simple, no initial tension is required to secure adhesion to the pulleys, and the flexibility is much greater.

A concrete instance of the combined advantages of chain driving is given by an investigation carried out into the working of grinding machines. These machines, illustrated in Figs. 10 and 11, were fitted with chain-drive equipment, inverted tooth chain drive for the actual grinding spindle, and roller chains in the other positions, and are engaged in grinding steel rods 7-8 feet long up to 0.375 in. diameter to an actual working limit of 0.00025 in. The original drive was by belt from 3-speed countershafts. These belts as usual, gave much trouble, due to slipping, which meant irregularity in the quality of the fine work required. Much time was also lost in adjusting the belts and trimming up the machines, and the life of the grinding wheels was uncertain. The application of chain drive resulted in 40% increase in the production of the machines for roughing work and 20% for finishing work, and a reduction in the power consumption of 26%.

In deciding upon the installation of a chain drive, it is always as well to consult the makers, who, of course have had a unique experience of almost every description of drive. In general, however, the selection depends upon the revolutions per minute of the shafts, the pitch and type of the chain desired, the bearing area of the chain, the number of teeth possible in the pinions, and the method of lubrication to be adopted. In order, however, to give some general indication of the many considerations that enter into the choice of the most suitable chain for given conditions, the following table of particulars, and illustration (Fig. 12) of a Hans Renold inverted tooth chain will be of interest. If a specially silent drive is required, the lower speeds given in Column E should not be exceeded, and a pinion used of not less than 21 teeth. It may be stated that in practice the minimum number of teeth is 19, and the maximum 120, and it is always preferable if possible to have the pinion of not less than 30 teeth.

It is a most uneconomical policy, often adopted, to try and reduce the linear chain speed by the use of pinions with a small number of teeth, which increases enormously the wear and tear due to increasing the angle of link bend, etc., whilst the impact effect is not diminished. Elaborate tests carried out by Messrs. Hans Renold seem to indicate that for a horse power, revolutions per minute and centre distance, the chain wear

INVERTED TOOTH CHAIN

		SPECIFICATION.							SELECTION DATA.				
		Width.							Normal h.p.			Revs. per min. for Normal h.p.	
			Overall.										
Pitch	Chain No.	Nominal (over working face)	Riveted joint.	Detachable joint.	Weight per foot.	Minimum breaking strength.	Actual Bearing Area	19T	25T	30T	Min.	Normal.
in.	To be given as reference.	in.		in.	lbs.	lbs.	sq. in.	A	B	C	D	E F
SEGMENTAL BUSH BEARING (Outside Guide Links) *British Patent No. 111,976 1916. Patented in U.S.A. June 1919.*												
.375	50032	.6	.87	1.00	.63	2100	.042	2	2.5	3	1325	2200-2600
	50034	.9	1.18	1.30	.87	2900	.063	3	4	4.5		
	50036	1.2	1.48	1.60	1.12	3750	.084	4	5	6.5		
	50038	1.8	2.10	2.22	1.61	5200	.126	6	8	9.5		
.5	50042	.8	1.11	1.28	1.0	3600	.075	3.5	4.5	5.5	990	1600-1900
	50044	1.2	1.52	1.68	1.4	4900	.113	5.5	7	9		
	50046	1.6	1.93	2.10	1.8	6500	.150	7	9	11		
	50048	2.4	2.74	2.90	2.63	8800	.225	11	15	18		
LINER BEARING (Centre Link Guided)												
.75	2521	1.8	2.01	2.30	2.55	8000	.23	7	9	11	555	1000-1200
		3.1	3.32	3.60	4.26	14000	.40	12	16	19		
1.0	2522	3.0	3.29	3.65	5.65	18000	.54	18	24	28	464	750-900
		5.1	5.32	5.70	9.20	28000	.90	30	40	48		
1.25	2523	2.7	2.95	3.45	6.65	19000	.60	22	29	35	408	600-720
		4.6	4.90	5.40	11.10	32000	1.04	38	50	60		
1.5	2524	2.9	3.27	3.80	8.55	30000	.79	30	40	48	340	500-600
		5.0	5.37	5.90	14.40	50000	1.36	50	66	79		
1.75	2525	3.1	3.53	4.15	11.0	37000	1.0	40	53	63	310	400-515
		7.1	7.49	8.10	24.5	76000	2.27	90	118	140		

ıries inversely as the square of the ımber of teeth in the pinion. In :neral it is best to use a light chain ı large driving wheels rather than heavy chain on small wheels, and the lubrication is efficient and the limiting speed not exceeded, the larger the pinion the better the results.

The following standard range of pinion wheels has been adopted by Messrs. Hans Renold Ltd., and although any special combination can always be supplied, it is very rarely necessary to go outside these limits :—

16 : 60, 19 : 64, 21 : 70, 23 : 74, 25 : 80, 30 : 84, 34 : 90, 40 : 94, 44 : 100, 50 : 108, and 54 : 120.

As regards the distance between centres, the normal distance is 40-50 times the pitch of the chain used, so that the arc of the contact between the chain and the wheel must not be less than 90 deg. The drive will work perfectly well below 40 times the pitch of the chain, but the wear and tear on the chain is increased and the life shortened. Also the centres should not be increased beyond 80 times the pitch of the chain with a limit of 10 feet, but vertical drives can be arranged at much longer centre distances. The shafts should be reasonably horizontal and parallel, and the two wheels in proper alignment, whilst the end-play should not exceed 0.2% of the centre distance.

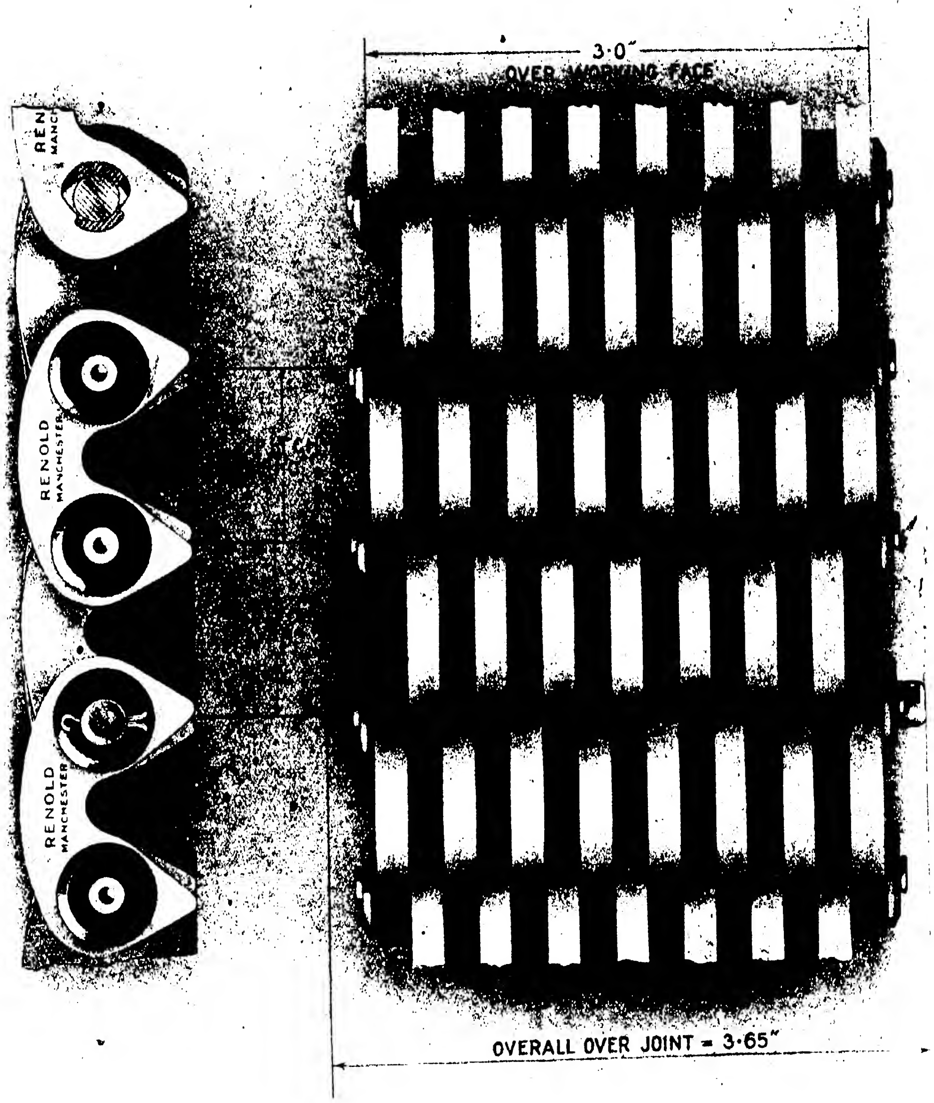


Fig. 12

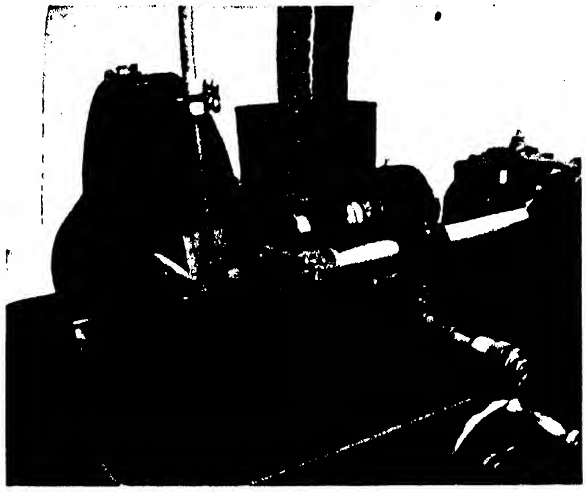


Fig. 11

A chain perhaps does not lend itself quite so well as a rope or a belt to the use of a jockey pulley, always an undesirable element. When a jockey has to be used with a chain, it must not be less than 25 teeth correctly cut, with at least 3 teeth in mesh engaged with the slack side of the chain. It should be arranged to be adjustable, and should then be locked definitely in position. A chain should never be allowed to run too slack, and the centres should be adjusted regularly or a link taken out of the chain, and it should be cleaned thoroughly at intervals with paraffin.

The chief point, however, in connection with a chain drive, especially for high speeds and difficult short distance jobs, which can be regarded also as one of its advantages, is that thoroughly efficient lubrication is required, and the best results are obtained by the use of a totally enclosed oil bath. The necessity of efficient lubrication will be obvious when we remember that the bearing pressure on the wearing surface, the joints, varies from 700-2,000 lb. per square inch, and such bearings require lubrication like any other bearing. By far the most efficient method, especially for anything over 20 h.p., and for all multi-strand drives, is an enclosed gear case combined with mechanical lubrication by means of an oil pump, as detailed in Fig. 13.

The arrangement will be clear from the illustration, the oil being filtered and forced continually by a small pump driven from the shaft by means of a "strap" or belt against the inside face of the chain as it is running. The pumps used by Messrs. Hans Renold are of the oscillating plunger type, being valveless and of robust and simple construction, and are of two standard sizes: (1) with a sump of 5 gallons capacity with a pump of ½ in. plunger and 1¼ in. stroke, delivering 4 gallons of oil per hour at 100 revolutions per minute, and (2) a sump of 10 gallons with a pump of 1 in. plunger and 1¾ in. stroke, delivering 20 gallons of oil per hour at 100 revolutions per minute. The correct oil delivery is 1-1½ gallons per hour per inch overall width of chain.

Since the great advantage of a chain drive is its high efficiency, it is poor policy, for the sake of a small extra capital outlay, not to adopt such up-to-date methods of lubrication, especially when at the same time the whole drive is entirely closed up free from all dust and dirt, absolutely noiseless, and does not stir up dust by causing currents of air. A very efficient method also is simply to have a deep well of oil in the bottom of the gear case with the chain running through it, with an oil thrower disc of larger diameter attached to keep the oil in better motion if the pinion wheel is very small. A less efficient method is by means of a drip lubricator, as illustrated in Fig. 14, with a splash guard so that the oil drips regularly on the inner surface of the chain.

The oil used must be of good quality mineral oil, medium heavy variety, which does not dry in the air, and if grease is used, it is best to avoid graphite greases, as they are apt to form a deposit on the chain which impedes lubrication.

The principles of design underlying chain driving are of an extremely complicated character, and include allowances for such points as the pull on the chain due to centrifugal force, as the chain travels at high speed (especially when over 2,000 feet per minute) round the driving wheels, and the catenary pull, important in the case of long drives and where the sag on the slack side of the chain is very small, together with the calculations for the limiting speed of the chain, that is, the speed giving the least combined centrifugal and working pull. For this reason, also, it is always advisable to consult the makers as regards any proposed installation. Once installed, of course, the drive is perfectly simple, and requires far less attention than a belt or rope.

Disadvantages

1. *Increased Cost of Installation.* The only real disadvantage of the chain drive in most cases is the increased initial cost as compared with belts and ropes, and especially for drives of long centres. It is difficult to give comparative figures which would apply generally for obvious reasons, especially in view of the different prices charged for belting of different qualities in the various areas of the country. The best method is to get comparative tenders for any given drive, as each

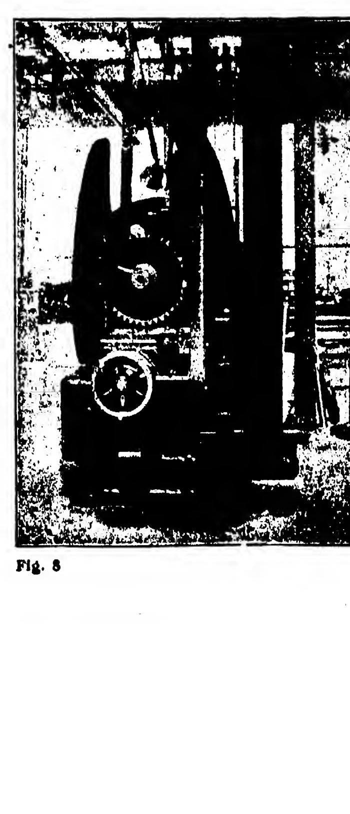


Fig. 8

job has to be decided according to the individual circumstances.

2. There are various other minor disadvantages of chain driving. One of these is the necessity of increased care and attention because of lubrication. Perhaps the most important, however, is the fact that if anything goes wrong the chain drive still goes on. For example, if some accidental stoppage occurs in a machine, the belt generally flies off and reduces the damage, whereas, in the case of a chain, this does not happen. On this account, therefore, chains cannot be used in a few special drives, such as that of mules in the cotton industry, although we understand chains are now being devised to cope even with this difficulty.

The whole question of chain driving is, therefore, a simple one of arithmetic, of increased capital cost against the much less annual cost of upkeep and wear and tear, and the saving in the power transmitted, averaging, as already stated, about 10% all the year round. In most cases it will be found that the chain drive is a handsome investment, especially for distances of less than say 20 or 30 feet centres, and it is the object of this article to draw the attention of the power user to the advantages of the chain drive, and the necessity of investigating the matter thoroughly for each individual drive. The fact remains also that the industries of Great Britain are, in general, much behind those of the United States with regard to chain driving.

The Use and Advantages of Electric Power in the Factory

By J. F. CROWLEY, D.Sc., B.A., M.I.E.E.

Dr. Crowley, in a paper read before the Royal Society of Arts, went very fully and systematically into the fundamental principles which govern the application of motive power under modern conditions. We give below a portion of the first part of this instructive paper, which will be continued in our next issue.

THE manufacturer has, in regard to the power he needs, two courses open to him :—

(*a*) To purchase power from outside suppliers.

(*b*) To produce power himself.

In regard to the first, in many parts of the country, notably in Lancashire, Yorkshire, Nottingham, Leicester and the woollen districts of Scotland, it is possible to purchase mechanical power under those "Room and Power" schemes which have done much for the starting of new industries in this country. In the case of a factory the author visited recently, some twenty manufacturers occupy one large building, buying room and power from the proprietor. Apart from "Room and Power" schemes, however, the only power it is open to the manufacturer to purchase is in the form of electricity. The decision of the manufacturer on this matter is in the main a commercial proposition governed by a comparison between the price at which power can be privately generated and electricity purchased. It should be affected, however, by important considerations, to which a commercial value can only be given with due regard to individual conditions. It can be claimed that the purchase of power leaves capital available for a more remunerative investment in manufacturing machinery; enables the management to concentrate its attention on the purely manufacturing side, and permits of a gradual expansion of manufacture to meet demands, since all that is needed for such expansion is the purchase of further motors. This latter advantage was particularly noticeable in connection with the mobilisation of industry for munition purposes during the war. It is safe to say that without the adequate supply of electricity Great Britain had available, the steady growth in the manufacture of munitions which was so necessary to the success of the war could not have taken place. It is stated that 95 per cent. of the new factories put down for the manufacture of munitions were electrically driven.

The further important point may be made in connection with the public supply of electricity, that there is, as has been pointed out, a steady tendency towards the taking of power from central power stations, and that as the load of these stations grows in amount and diversity, their generating costs are certain to fall. The cost of coal per unit generated is only one of the items affected by an improved load factor, and it was shown recently that an increase in load factor in a Dutch station of from 40% to 56% would reduce the coal consumed per Kelvin from 1.87 to 1.7 lb.

It need scarcely be pointed out before leaving this part of our problem that the merits or demerits of electrical driving are not determined by a decision as to the purchase of power. The manufacturer who decides to make his own power can convert it into electricity for power distribution throughout his factory.

Electricity for public supply purposes is in general distributed at high pressure for large industrial loads and at low pressure only for lighting and small industrial applications. For distribution to the motors in the factory it is usually reduced to a moderately low standard pressure, such as 500 volts. This is done by means of static transformers which are sometimes placed in a substation from which a number of mills are supplied, or more generally separate transformers are provided for each factory. It should be pointed out here that some public supply companies in India so arrange the terms on which they supply current as to offer strong inducements to manufacturers to avoid the installation of

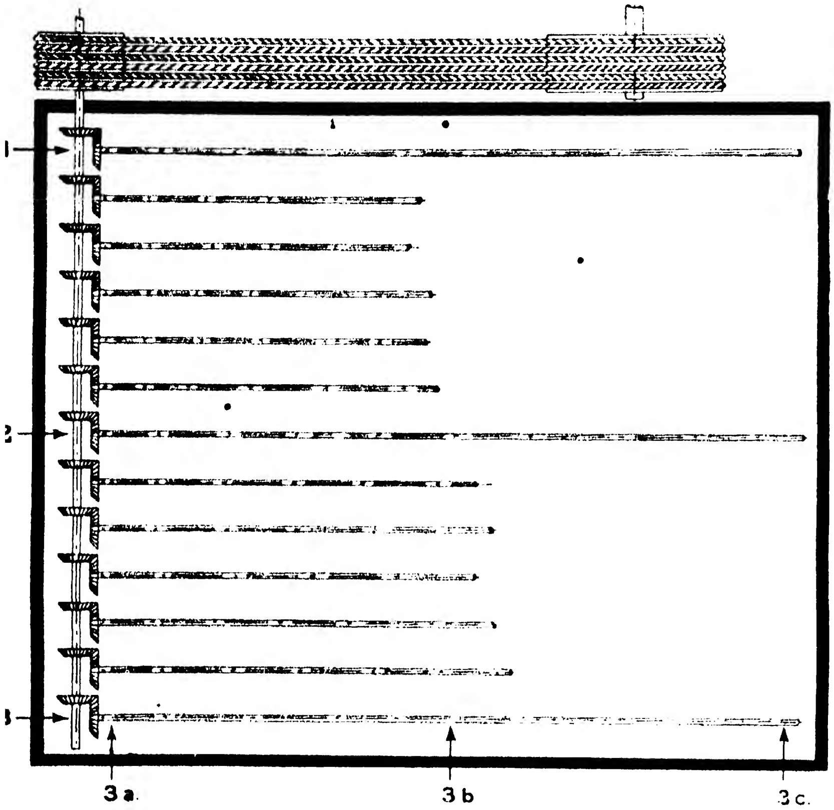


Fig. 1

transformers and apply high tension current direct to the motors. This is a practice which, in general, cannot be too strongly deprecated. High tension motors suffer from several drawbacks where ordinary industrial power applications are concerned. They have perforce to be of large size, since small motors cannot be built for high pressure, while because of the element of danger attending their use, it is not always possible to place them in the best position from a driving point of view. These disadvantages tend to nullify the flexibility in application of electricity for driving, which, in the author's opinion, forms its greatest claim to consideration.

A practice also that appears to be developing in India in connection with the public supply of electricity is the undue penalising of the manufacturer if the power factor of his installation fails to reach a certain figure. This clause in electricity supply contracts is working out in practice in a manner that the supply engineers can scarcely have anticipated. The manufacturer, knowing that he is liable to suffer a severe penalty, if not to have his power cut off, if his power factor does not reach the value fixed by the supply company, and being informed that large motors have a higher power factor than small motors and high speed motors than slow, is induced to put down large and frequently high speed motors. This again destroys flexibility and operates against the use of motors of a sufficiently low speed to be direct coupled to line shafting.

A more general adoption throughout India of the system in use in Calcutta is desirable, by which the reduction in power costs that would accrue to the supply company from an increase in power factor is calculated, and the greater part of the saving is credited to the consumer in the form of reduced charges, a corresponding provision being made for an increased charge for a low power factor. The author is informed that under the arrangement now in force it would pay a customer to instal apparatus to raise his power factor, since, by so doing, he would get a reduction in current charges that would pay a dividend on his investment. Without such an equitable contract the supply company stands to gain and the manufacturer to lose by a too rigid adherence to standards which may militate against good engineering. Any restrictions that tend to make the application of electricity less flexible tend to make its adoption less rapid.

Apparatus to improve power-factor may be installed in the central power station or in the factory itself, preferably in the factory, which is the seat of the trouble. The following are the more usual methods of improving power-factor :—

(*a*) Static condensers.
(*b*) Synchronous motors.
(*c*) Synchronous asynchronous motors.
(*d*) Phase-advancers.

When the manufacturer decides to put down his own power plant, he has in practice three types of prime-mover to choose from :—

(1) The modern reciprocating steam engine.
(2) The steam turbine.
(3) The Diesel or the semi-Diesel engine.

Neither the Diesel nor the semi-Diesel have, even in India in close proximity to the oil fields, made much progress in industry. This is perhaps due to the comparatively large load furnished by individual mills, the expert attention required by this class of engine, and no doubt also to the speculative nature of the price of oil. The development of fresh oil-fields, a greater steadiness in the price of oil, or improvements in the engine, may lead to its greater employment. The author sees no reason to anticipate such a development, however, and feels that any cheapening of the price of oil would lead rather to its use as a fuel for steam boilers, for which purpose it is finding a considerable outlet at present.

The Prime Mover

The real fight for supremacy in mill-work lies between the reciprocating steam engine and the steam turbine. The steam turbine is smaller and lighter than the reciprocating engine ; it can be housed in a smaller building and requires lighter foundations than its rival ; its first cost is lower, and, assuming that a good vacuum is maintained, and that the size of unit is not too small, its power costs are lower also. It is, however, when we come to the principles that should underly the application of power that the most signal advan-

tages of the steam turbine begin to appear. The turbine, being a high speed rotary engine, instead of a slow speed reciprocating engine, provides a turning torque on the shafting which is without cyclic variation; a fact which contributes very largely towards the attainment of high standards for speed variation and cyclic regularity through the factory system. Taken in conjunction with the other factors mentioned, it has led to the growing adoption of the steam turbine as the prime mover for private installations. It should be generally recognised, also, that so far as power production on a large scale is concerned, the steam turbine is supreme in all cases where water power is not a serious competitor. Its almost universal adoption by central station engineers whose business is the maintenance of a reliable supply of power at a low cost, may be taken as a clear indication that it has proved itself to be the most satisfactory prime-mover, and, in the author's view, its exclusive adoption for all factory installations exceeding 1,000 kw., when power is not purchased, is only a matter of time.

The Principles of Power Application

It cannot be too clearly emphasised that the production of a manufactured article of a quality and at a price to compete is the primary, if not the only objective, of the manufacturer, and that power is only one of the many agents he employs to secure this end. With this in mind, the following broad principles may be laid down as governing its application :—

(*a*) The building requirements for power purposes must be little, if at all, in excess of those required by the manufacturing processes.

(*b*) There must be no interference with the lay-out of the manufacturing plant to suit the manufacturing processes, lighting, accessibility and supervision.

(*c*) The power equipment must be reasonable in first cost and in running costs, and finally,

(*d*) It must be possible to secure the maximum production from the machines :—

(1) By ensuring reliable running.

(2) By maintaining the average speed of the machines within the recognised limits.

(3) By keeping the cyclic variation in speed of the shafting within defined limits.

(4) By facilitating prompt starting in the case of machines that start and stop frequently.

These are the basic principles that it is now recognised should govern every application of power to industry, and it may be said at once that the engineer can to-day satisfactorily meet each one of them, and that no reason exists on engineering grounds for any departure from their rigid application. When we proceed, however, to deal with matters quantitatively, we find these are affected by :—

(1) External conditions, such as climate, etc.

(2) The nature of the manufacturing processes; and

(3) The peculiarities of the machines to be driven.

Power requirements are affected by humidity and by temperature, which, by altering the tension of ropes, belts, and spindle driving bands in textile installations, and the viscosity of the lubricating oil, seriously influence the power required, and, indirectly, the speeds of the machines. This effect is most serious in the morning and after week-end stops, and in India is particularly noticeable during the monsoon, when, occasionally, the increase in tension of the driving ropes and bands produces a load with which the engines have difficulty in coping.

The nature of the manufacturing processes and of the particular machines employed also influence to a marked degree the limits of speed variation it is desirable or practicable to lay down.

Speed limits that would be reasonable in a textile factory where the material runs through continuously could not be obtained in a tannery where separate hides have to be successively passed through the machines, nor would it be possible to obtain that degree of regularity in the driving of a mangle or a loom that might reasonably be anticipated with a ring or a flyer frame.

As regards the first requirements governing the application of power, little comment is needed. Any excess in building specially required for power generation or application means additional capital expenditure, not directly remunerative. This may become serious if, for instance, large motor alleyways are insisted on, and

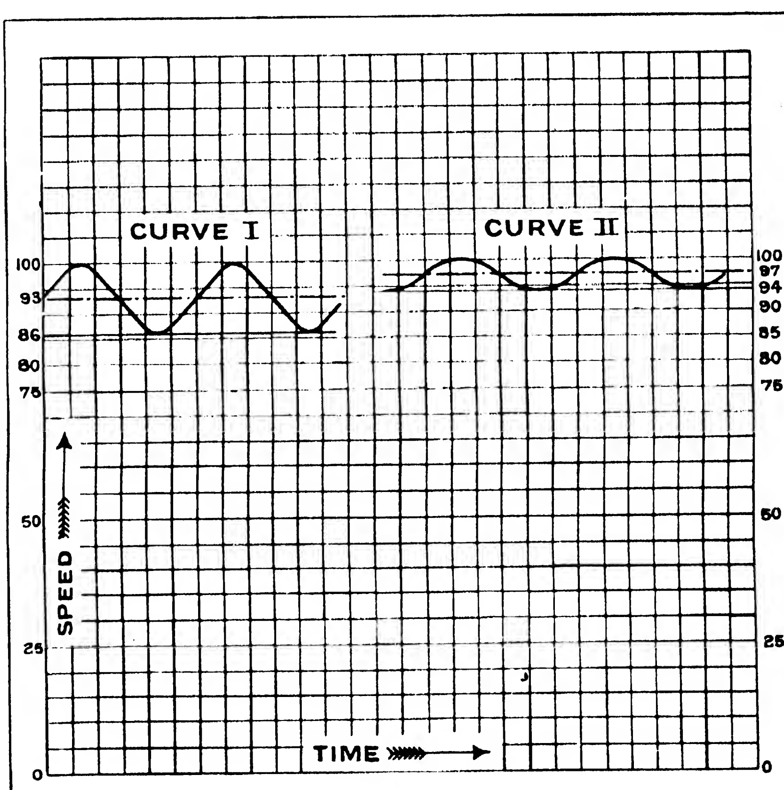


Fig. 3

in cases where only a limited space is available, the productive capacity of the manufacturing plant may be seriously reduced.

With regard to the layout of the manufacturing plant, this should be carried out on the lines that best suit the manufacturing process and economical production. It is, for instance, in general desirable that, so far as possible, the raw material should enter at one end of the building and pass through without interruption to the packing and forwarding departments. The driving system should permit of this being done, and should not, in any way, by reason of shafting requirements, etc., interfere with the internal economy of production.

The older mechanical drives, where heavy bevel gears and other mechanical transmission devices were employed, did interfere, to a serious extent, with factory layouts, and prevented the adoption of arrangements best suited to manufacturing conditions.

The equipment for driving, also, must not be excessive in first cost, because here, too, it should be noted that any capital expended on ancillary machinery, such as the power equipment really is, is capital that could be usefully employed on the productive side.

The requirements we have just been considering are intended to secure that the maximum amount of productive plant is obtained from the capital available, and we have now to consider how far the maximum production can be obtained from the manufacturing plant actually installed. This is secured, in so far as it depends on the power plant and transmission system, by having a reliable installation not subject to stoppages, and by securing that as steady a speed as possible is maintained throughout the factory.

Where a steady running prime mover drives directly a machine which does not provide a cyclic variation in load, the speed of the shafting and transmission system generally should be perfectly uniform. In no system, however, is it possible to secure such uniformity, and it becomes necessary to consider what variations occur and within what limits those variations can be kept. The variations usually met with arise from three causes—

(a) Irregularity in turning movement of the prime mover.

(b) The starting and stopping of individual machines on a line shaft.

(c) Cyclic variations in torque of individual machines.

The effects produced by irregularity in turning movement of the prime mover are two-fold—

(a) Variations in average speed of long period due to variations in load, or to poor governing

(b) Cyclic variations due, for instance, to reciprocating moving parts.

Governing and regulation have been so far improved that it is now possible to maintain the average speed of an engine within sufficiently fine limits, and the real trouble in factory drives is found to arise from rapid fluctuations in speed which are superimposed on the average speed. These speed fluctuations, which are generally of high frequency, are commonly referred to by mill engineers under the heading of "cyclic irregularity."

It may be desirable at this stage to consider permissible limits for speed variation based on experience of what can be obtained, and is obtained, in practice in textile work. A short time ago, in a series of articles* published in the *Textile Recorder*, a writer, evidently with experience, maintained that with modern systems of governing and regulation, it should be possible to keep the speed variation of a reciprocating steam engine within 1 per cent. and 1½ per cent., and that a variation beyond 1½ per cent. to 2 per cent. should not be tolerated. He found that at the driven end of the first motion shaft the speed variation had usually increased to a much higher figure, such as 5 per cent., but that it should be possible to design the layout so as to keep it below 3 per cent. at this point, and that a higher figure should not be permitted. Proceeding now along the shaft from the driven end, he found a steady increase in speed variation until at the extreme end figures varying from 9 per cent. to 17 per cent. were reached.

It was found, however, that when the speed variation at any point exceeded 6½ per cent., the effect on the spinning was distinctly noticeable, and weaving on automatic looms was impossible. This writer, therefore, gave 6½ per cent. as the maximum permissible speed variation that should be allowed in any part of a textile mill.

*Textile Recorder, Manchester, Feb. 15, 1911, to Feb. 15, 1912.

The figure was clearly what the writer felt he could hope to obtain in a mechanically driven mill, and the fact that he was willing to permit of a speed variation, the harmful effect of which was noticeable on the machines, was clearly because he had little hope of obtaining better results in mills driven on the older systems. Tests the author took in India in a good factory have shown that a speed variation of 1 per cent. near the engine became 3½ per cent. at the beginning of the furthest loom shaft, 9 per cent. at the middle of the shaft, and 14 per cent. at the end. Fig. 1 shows the layout of the shafting in this factory, and indicates the points at which the readings were taken, while Fig. 2 shows a photographic reproduction of the actual readings themselves, the small vertical scale divisions corresponding to a speed variation of 1 per cent., and the distance between the horizontal points corresponding to three-quarters of a second, or six seconds over the scale. The difference in the speed variation at points 3 and 3a is specially to be noted, and also the rapid increase in speed variation at 3b and 3c. The author ventures to say that at no part of a mill shafting system should the speed variation exceed 3 per cent. to 5 per cent., and he looks forward to the day when every industrial power system will be tested and passed for speed variation on a standardised basis, to limits such as these, before being taken over.

The effects of speed variation as shewn by experiments are that when it exceeds a certain limit some machines cannot be run at all, the production of other machines, and in particular of spinning machines, is affected through breakages, and the production of all machines is reduced below the maximum of which the machines are capable for reasons that will be clear from the diagram shewn in Fig. 3. The first curve, I, in this diagram shows a speed variation of 14 per cent., giving an average speed of 93 per cent., or 7 per cent. below the maximum speed attained. The second curve, II, illustrates an attempt to improve the drive, and shows a speed variation of 6 per cent., giving an average speed of 97 per cent., or only 3 per cent. below the maximum. The fall in average speed illustrated by the first curve represents a direct loss in production of 7 per cent., and is a feature of speed variation, to which all too little attention is given. The same remark applies to the progressive character

of the speed variation from the engine to the extreme end of the most remote line shaft. From a manufacturing point of view, the rapid oscillations of shafts which result in the speed variations we are now considering,

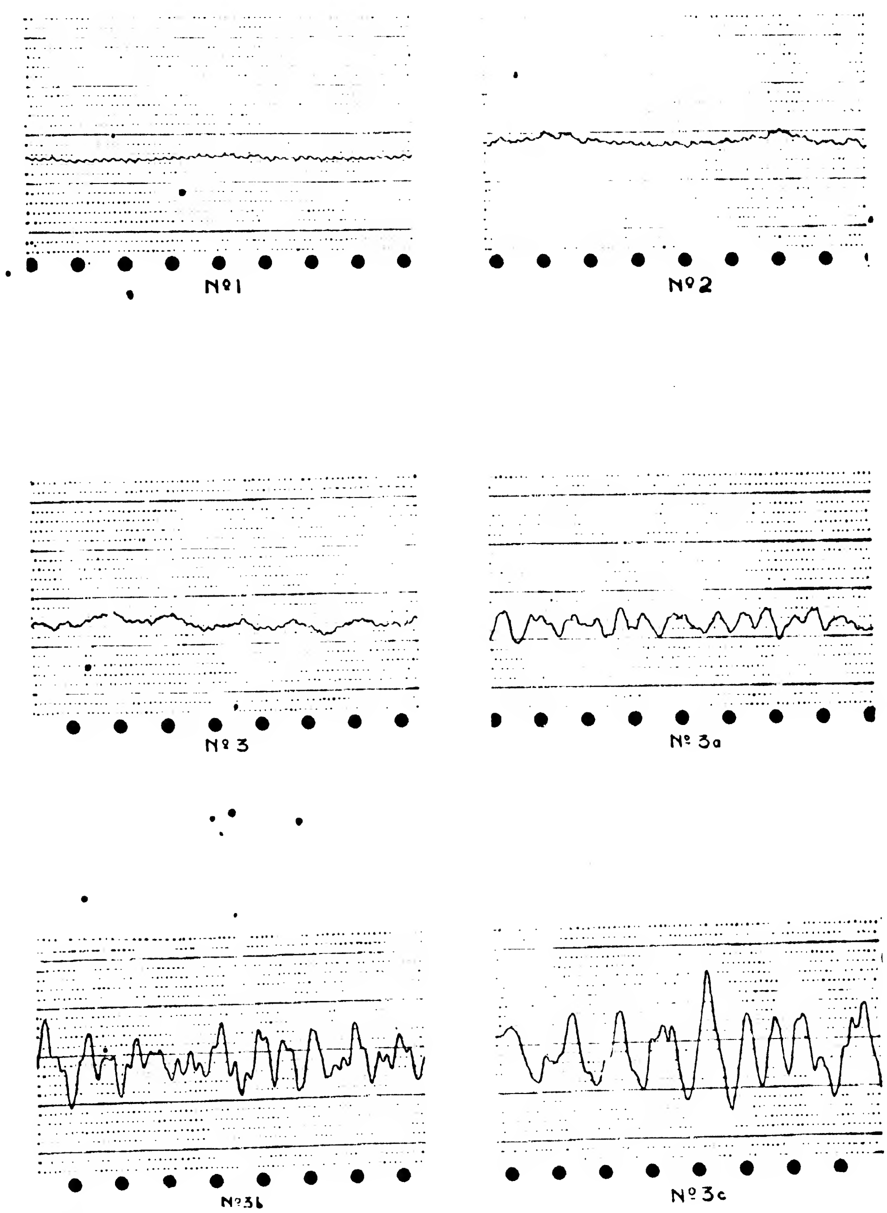


Fig. 2

are more serious than the slow variations in average speed to which reference was made earlier, and are produced in the main by the starting and stopping of machines, and by the irregular torque of individual machines. For a given thickness of shaft they are less with fast shafts than with slow, and with short shafts than with long. They are, on the other hand, stimulated by any cyclic variation of speed of the prime-mover.

The author believes that many of the mistakes made in connection with the application of power to particular industries are due to a lack of knowledge on the part of those making the application, of the processes employed, and of the peculiarities of the machines used, and to a lack of appreciation also of the needs of the industry and of the personal equation of those employed in it. He feels, therefore, that he need offer no apology for entering in some detail into these elements, choosing for this purpose an industry which furnishes problems to the power engineer typical of those he is likely to meet with in most textile industries and in many industries of a similar character.

(To be continued.)

The Allen Hydrautomat

To meet the wishes of a number of our readers, we give below a detailed description of the Allen Hydrautomat, by courtesy of Messrs. Allen Hydrostatic Pump Syndicate Ltd., London

A SELF-OPERATING means of lifting water in any quantity to any desired height, without the use of any standard equipment, such as pumps, rams, turbines, or water wheels. It has no moving parts other than an inlet and outlet sluice-gate. It is entirely self-contained, and provides its own motive power by the employment of two natural sources of energy; the weight of a column of water—and the pressure of the atmosphere.

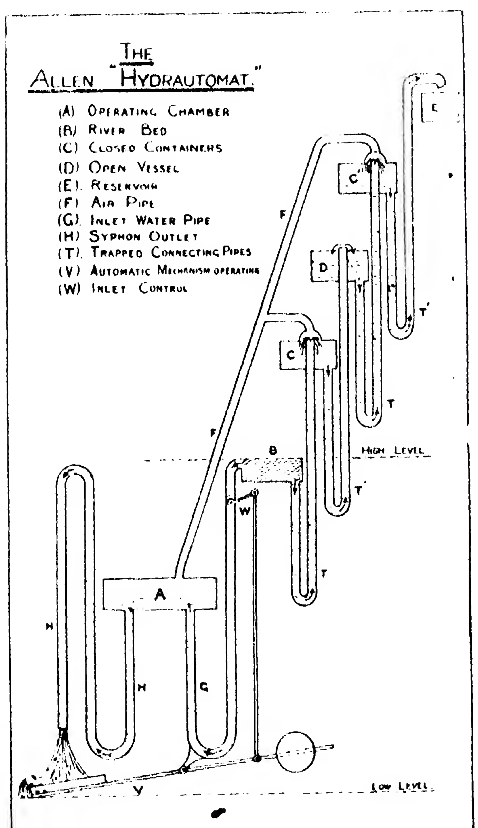
The operation is continuous. It requires no housing, attention or supervision. There is nothing which can wear out, or lose adjustment. It may be constructed from timber, steel or concrete—in fact any material which can be made watertight, or practically so.

The cycle of operation is so simple as to be baffling on first inspection. The effect seems to flout the rule that water cannot move uphill. In the hydrautomat it is pushed and pulled up by successive impulses. One is that of automatically compressed air. The other the pressure of the atmosphere working against a vacuum. These impulses are self-induced, and follow each other in continuous alternations.

Avoiding technical details as far as possible, there is unlimited scope for a fool-proof device which will abstract from a flowing river (or from a tidal flow) a given proportion of its water, and raise it to a desired height. In all countries there are large streams on which hydraulic power developments are not feasible, owing to the small amount of fall (or "head") available for driving turbines. It is axiomatic that the lower the head, the greater the cost per horse-power developed. In all countries there are arid, or semi-arid, areas, within reasonable distance of rivers, but the local conditions, plus the cost of pumping, have made irrigation impossible. At other points there are tides which cannot be economically used for power on account of the enormous expenditure involved.

In each of the above cases there may be ample water, but the water is not in the right place. The farmer on the hillside is ruined by drought while he looks down at the river in the valley. The tides ebb and flow, with their stupendous energy still unharnessed. The river glides to the sea, and, because its fall is so gradual, turns nothing but a few millwheels.

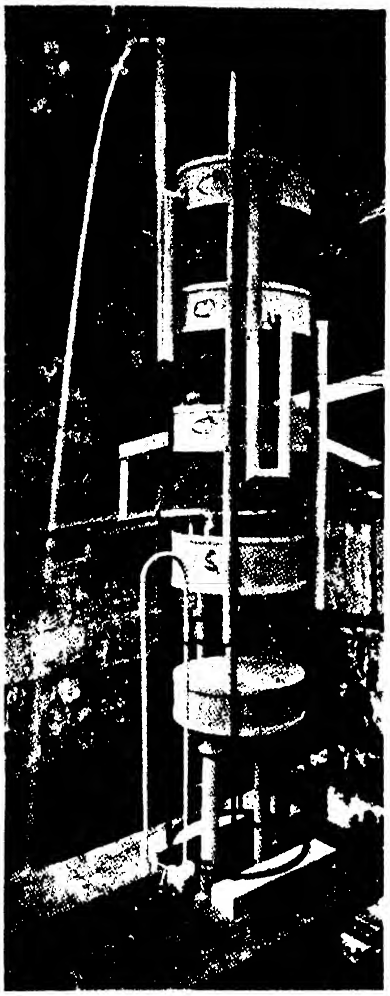
These are the cases, or some of them, to which the hydrautomat is directly serviceable. Furthermore, it is the only thing that can serve. Nor has the progress of scientific research yielded anything so far which has a parallel application. It would not be applicable did not the theory march in step with the great forces of nature, and draw from them both its simplicity and efficiency.



Diagrammatic Sketch showing Working of Hydrautomat

PRINCIPLE OF DESIGN.—In order to describe the apparatus as lucidly as possible, take the case of a river on which there can be had a head, say, of six feet. This head may be developed very cheaply, especially if it is only desired to use a part of the flow for motive purposes. In the accompanying diagram, call the upper level the headrace, and the lower the tailrace. There are six vertical feet between them. At the half-way point, or lower, or higher, if desired, there is constructed, of any suitable material, a closed tank, proportionate in size to the capacity of the apparatus. This is called the "operating chamber" (A). It is supplied with an intake pipe (G) from the headrace, and from it there goes a discharge pipe (H) to the tailrace.

Above it, and to the required height, is constructed a flight of alternating closed (C) and open tanks (D), which may be either over each other, or placed like steps up a hillside. These are interconnected by water-sealed supply pipes (T). Each of the closed tanks is, in addition, coupled to the operating chamber by an air conducting pipe (F).



A.—Pressure Strokes

As to size, the combined capacity of the closed tanks is equal to that of the operating chamber.

From the top, a duct (E) conveys the lifted water to the desired point.

That is all there is to the hydrautomat.

Operation is confined to two strokes: pressure—then suction.

PRESSURE.—This is created by the weight of the water column which flows into the operating chamber (A) from the headrace (B). Its effect is to compress the air in this chamber, and force it out along the air-conducting pipe (F), whence it enters the overhead closed tanks (C). The effect here is that the water in these tanks (which has been lifted by the preceding stroke) is, in its turn, forced out, and pushed up through the connecting pipes (T) into the next tanks. These are open ones. This water cannot escape downwards again, as the open end of the pipe by which it has come is slightly above the surface at the completion of this stroke. The compressed air, therefore, can only force the water upwards. One flight is thus accomplished. At the end of this pressure stroke, the operating chamber and open tanks are full of water, but the closed tanks are full of air.

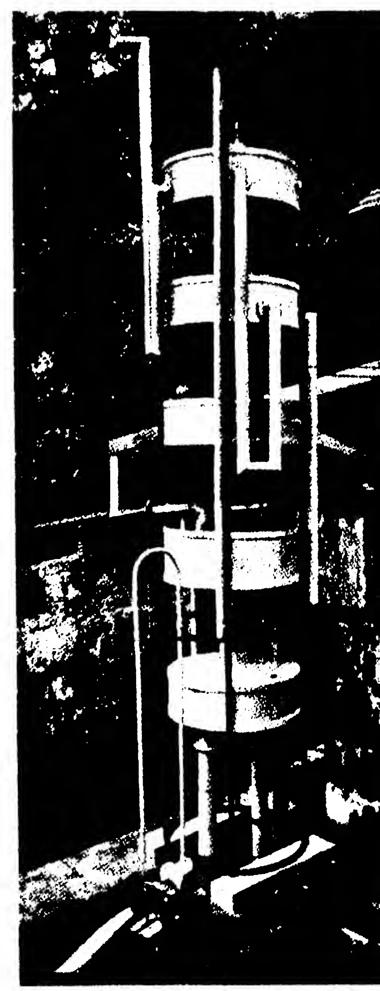
SUCTION.—This is governed entirely by the normal pressure of the atmosphere on the earth's surface. The contents of the operating chamber are automatically drawn down and discharged into the tailrace. Simultaneously the inlet sluice from the headrace is automatically closed. A vacuum is thus created in the operating chamber, and this vacuum extends to all the higher closed tanks through the medium of the air-conducting pipe. In consequence, the water in each open tank (these being now full) is sucked up one flight into the next higher closed tank. At the end of this suction stroke, the operating chamber and open tanks are empty, and the closed tanks are full of water. The inlet from the headrace is then automatically opened, the pressure water re-admitted, and the pressure stroke recommenced.

ABSENCE OF VALVES.—The pipes between the tanks are all water-sealed, so that all non-return valves or mechanical checks are dispensed with, and the downward escape of compressed air is prevented. It will be seen, then, that the conducting pipe only transmits the actuating agent from the operating chamber, in which that agent is developed. First, as compressed air, it forces water up one flight from the closed tanks into the open ones. Next, by the pull of a vacuum (which is atmospheric pressure set free to act), it draws the water up a further flight from the open tanks to the closed ones. There is no escape from this sequence. It is a matter of push and pull—push and pull.

PRIMING.—The hydrautomat is automatically primed. A cock is inserted in the conducting pipe between each of the closed tanks. These cocks sectionalise the apparatus. Also there is placed on the operating chamber an air vent, used only in priming. When the chamber is entirely empty, this air vent is opened, and operating water admitted. The air vent is then closed, as also the cock between the two first closed tanks. The operating chamber being then discharged, a vacuum is formed, and the lowest closed tank at once filled from the source of supply. The next stage is accomplished by opening the next cock in the conducting pipe, and so on until the system is entirely primed.

LOW PRESSURE EMPLOYED.—The system is equally effective at both low and high lifts, and at no point is there more than the pressure due to the operating head, no matter what the height of delivery may be. In the above example, the maximum pressure is less than one and a half pounds per square inch. This is another striking advantage over the ordinary system of pumping. The height required is reached by carrying the series of closed and open tanks, together with the air-conducting pipe, to the desired point.

Such, very briefly, is the action of the hydrautomat—the alternating



B.—Suction Stroke

pressure of water and atmosphere. One being shut off; the other does its work. The sequence is positive, and the recurring pulsations, being but obedience to natural law, are inevitable.

INLET AND OUTLET CONTROL.—In the diagram given, the principle of the supply and discharge sluices is shown as to clearly demonstrate their operation. In the hydrautomat, as erected and running at Carshalton, the arrangement is equally simple, but differently applied. The long invert of the discharge pipe (H) has been eliminated, and it ends just beyond the first bend. Here is placed the outlet sluice, itself being in balance with the inlet sluice controlling the entry of water to the operating chamber. From the bend a small pilot syphon is led, and discharges into a self draining bucket connected by wire cable with the inlet control.

On the completion of the pressure stroke this bucket is filled by the pilot syphon, and by its weight opens the outlet. At the end of the suction stroke, the bucket, being now drained, is over-weighted by the inlet sluice and rises, thereby closing the outlet from the operating chamber. This very simple action maintains the positive action of both inlet and outlet.

INDEPENDENT SUCTION.—It will be observed that in the above example one portion of a stream elevates another portion of itself. But this is in no way essential. The hydrautomat may conveniently take pressure from a muddy river in order to lift the clean flow of an adjacent spring.

AUTOMATIC AIR CONTROL.—It was found, as anticipated, that unless special provision were made, there would be a small but constantly increasing addition to the air column in the hydrautomat, due to the fact that air bubbles must often be carried in by the operating water, and also as the result of the liberation by agitation of some of the air contained in water itself.

To meet this, an extremely simple arrangement forms part of the hydrautomat, whereby excess air, whenever it collects, is automatically discharged, and the air column kept at exactly the right length. This relief device comes into action only when excess air has accumulated. Furthermore, what air remains is reduced to atmospheric pressure just before it is rarified by the suction stroke.

FLEXIBLE DESIGN.—An important advantage is that the principle of the hydrautomat admits of it being constructed in varying forms to suit varying requirements. In addition to the designs shown in the diagram and photograph, it may be built in the shape of a self-contained tower, a stand pipe or silo. In this case, there are merely successive sections, separated by floors without any air spaces between. The piping may be all inside, and itself be of concrete—or even glazed tile.

Another very simple method is to arrange the hydrautomat in successive steps on a hillside, and place most of the piping underground. It will be understood that the operating chamber may be installed at a considerable distance from the open and closed tanks. This involves merely the lengthening of the conducting pipe.

The principle being thus fully described, the photographs taken at Carshalton require little comment.

"A" shows the pressure stroke, with water issuing from the delivery. "B" the suction stroke, with the operating water being discharged.

It will be seen that the rapidity of the cycle depends entirely on the speed with which the operating chamber is filled and emptied, and is merely a matter of pipe sizes, given a suitable supply of water.

In these photographs will be noted the small pilot syphon above referred to, which fills the self-draining bucket. In "B" this bucket can be seen depressed, having been filled by the pilot syphon, and suspended from the wire cable running from the overbalanced inlet sluice.

In "A" the syphon is not in action, because the apparatus is on the pressure stroke, and the water in the operating chamber has not risen high enough to make the syphon discharge.

EFFECT OF LEAKAGE.—Should any leakage occur in the hydrautomat the operation will not be stopped, but only affected in proportion to the size of the leak. If this is the escape of air outwards on the pressure stroke, it means that while less water is being delivered, there is also less air to be exhausted before what remains is rarified by the suction stroke. If an excess of air is sucked in during the latter, it means that this excess will be automatically vented at once by the air relief attachment already mentioned.

THE ESSENTIAL PURPOSE.—In a broad sense, the office of the hydrautomat is to convert the contained energy of large quantities of water at a low head into that of a smaller quantity of water at a high head—or to compel a stream to hoist part of itself up over the land for domestic or agricultural purposes. The principle is fixed. The method of application is determined by local requirements.

The hydrautomat has been patented in all countries. The issue of these world rights for an apparatus of profound simplicity is a tribute to its revolutionary character. The German officials extended their patent researches in this connection back into the history of science as far as the days of the Alexandrian mathematician, Hero, in the third century, and investigated the attempts of Giambatista della Porta, an Italian physicist, in the sixteenth century. It appears that in the world's inventive record the principle has only been remotely approached. It has never hitherto been attained. The hydrautomat stands to-day as the fullest realisation of the dream of the engineer—"the application of the forces of nature to the usage and benefit of man."

Hydraulic Rams

By E. W. ANDERSON, Assoc.M.Inst.C.E., M.I.Mech.E.

The following is the discussion which took place on the above paper, which we published in our November issue.

MR. R. H. PEARSALL said that while he was not in practice as a hydraulic engineer, his father had made important contributions to the subject. The late Mr. H. D. Pearsall had been interested in large rams for hydraulic mining and irrigation, and such rams were limited by the shock on closing the valve. He therefore designed a ram resembling the Anderson ram, in the presence of a rising pipe to the delivery valve plate, but this pipe or chamber was adapted to empty the water and fill with air at each stroke. This air provided a cushion to the water shock, so that the main valve was able to be shut before the pressure in the ram had risen appreciably. In order to prevent the large main valve from hammering on its seat, it was controlled in its motion and operated by pendulum gear, and a small motor. The latter was driven by the air which passed the delivery valve each stroke.

In this way 2-ft. diameter rams had been successfully operated, and even larger rams might be made. By extending the air-chamber, the ram might be turned into an air-compressor of very high efficiency, for it had been found that the cold wet air compressor chamber gave a compression more akin to isothermal than to adiabatic. The speaker had the privilege of assisting his father in the design of such a compressor, which was now supplying rock drills in Devonshire, and worked during the war with practically no attention.

Another form of ram was practicable for such work as irrigation, where both fall and lift were small. This was substantially a "U" tube, in which the water oscillated. A valve was provided at the bottom of the "U" through which water flowed to waste, gaining energy in the long or fall leg. Upon closing the valve, the water flowed on up the riser leg and spilt over into the high level channel. The reverse oscillation emptied the riser of water, and the stroke was repeated. In all these cases it was possible to calculate and foretell the actions and periods with reasonable accuracy.

The paper was a valuable record of experiment, and did not attempt to analyse the actions taking place. While we restricted ourselves to the small ram, this was probably the right thing to do, but it was not possible in the larger cases where analysis was most important. The difficulties the author had had to meet were apparent when the results were plotted, for many disturbing factors were seen to prevent the drawing of good curves.

With regard to the length of drive pipe, it was clear that the shock and its losses were largely confined to the ram itself, so that they would not be increased by increase of drive pipe. But the energy in the water would be increased with increase of drive pipe, so that the relative loss was less, and the efficiency greater. This would continue to be the case until the greater length of pipe introduced frictions which reduced the efficiency again.

For efficiency the flow forms were important. His father had paid much attention to this, providing divergent forms beyond the main valve with success. It would appear that the weight of the main valve was a dynamical question, depending on the proportioning of the design as a whole. On plotting Table II (page 198), a curious drop in efficiency with low-lift ratio was noted with the higher main valve lift.

Mr. J. R. Easton said he did not know of any rams at work in Birmingham, but he could remember one at Shifnal, and there were three at Patshull Park (the Earl of Dartmouth's seat) which had been working since 1856.

With regard to the tables given, the efficiency figures had been deliberately taken on the low side for commercial reasons, so that they could be practically certain that the ram supplied would give the results mentioned. He noted that Mr. Anderson said that the bodies of the rams were left rough, as cast, but it was his (the speaker's) practice to have the bodies machined for about 2 inches below the lip of the outer valve. To obtain the different ratios from 18 to 1 to 58 to 1 with the 2-in. ram mentioned in the paper, the stop-valve on the rising main was closed, and a bib-cock inserted between the valve and the ram, with a pressure-gauge. By throttling the bib-cock, the amount delivered by the ram under different heads could easily be obtained.

With regard to the durability of the ram, he knew of one which had been at work for over 100 years near Tunbridge Wells, and was delivering water both to the stables and, at a higher level, to the house. Some time ago the ram would deliver to the stables, and not to the house, and an engineer was called in who advised the expenditure of £150 on a hot-air engine to do the necessary pumping, but eventually the owners got in connection with his firm, who found that the valve was leaking. On supplying a new valve, the ram worked as well as ever, and was still at work after its 100 years' service. He knew of another case of a ram where the valves had not been touched for twenty-seven years, and when they were examined it was found that the ball of the inner valve had nearly cut through the seating. The ram was delivering a third of the water it should have done, but was still working, in spite of the bad state of the valves. In another case, where a house had changed hands, the purchaser made no inquiries as to where the water supply came from, until after about four years it suddenly ceased, and then they began to look into matters, and found that they were not supplied by a water company, but by a ram, and that a leaf had got between the valve and seat, which had stopped the ram. This was removed, and the ram worked as well as ever.

With regard to the "dirty-water" type, or compound ram, he knew of a 5-in. ram by Messrs. Green & Carter, of Winchester, with 18 ft. fall, raising 2½ gallons per minute to a height of 305 feet, working with an efficiency of 64 per cent. Also one with a fall of 40 ft. against a head of 150 ft.,

delivering $6\frac{1}{2}$ pints per minute, with an efficiency of 60 per cent. All the efficiencies given were obtained under ordinary working conditions.

He produced for inspection the original Montgolfier patent, dated 1816, with the assignment to his grandfather and the coloured drawings deposited at the same time; also a patent for a compound ram, which clearly foreshadowed the present arrangement of dirty-water ram, though he could not find out that any were made at that time.

Mr. J. P. Udal said that after what he had heard, he need not question the reliability of the appliance, but he had more than once come across such a ram in South Africa working all by itself in some out-of-the-way rocky gorge, and he would like to know how it was controlled, certainly not by closing the delivery pipe. He wondered whether somebody had to go to the ram, which was often in an inaccessible position, to stop it, or was the surplus water merely allowed to overflow. He concluded that, in any case, under such conditions, efficiency was not a material matter. He asked, also, what was the largest size of ram made?

Mr. A. Goldie Engholm inquired what protection was necessary against frost.

The Chairman (Mr. E. C. R. Marks) said that he had once stayed at a house in Pembrokeshire where there was one of these rams 300 or 400 yards from the house, and the only trouble was that he had to go there occasionally to take out the dead leaves which choked the ram or held up the valve and prevented its working, because there was not an efficient strainer to keep it clear. He noticed that the author had said that the ram would not work without an air vessel on the delivery side; he could not understand why this should be, as it would appear to him that the ram ought to work whether there was an air-vessel or not. He raised the question as to the pollution of the drinking water by the dirty water operating the ram, and would like to know whether this did not occur when the piston got leaky, and whether the sanitary inspectors would pass it, if worked by a polluted stream.

Mr. E. W. Anderson, in replying, said he quite remembered being present when Mr. Pearsall's father read his paper before the Institution of Civil Engineers. He thought his firm had never made rams over 6 in. diameter, and they generally recommended 4-in. rams as the largest desirable size. They had put down as many as eight 4-in. rams, side by side, in preference to putting down one large one. With regard to the old ball-valve, it was no doubt more difficult to repair than the flat valve, but worked satisfactorily, though it was not so efficient. A telegram had once been received at the works, "Ram won't work," and on sending over a workman to see what was the matter, he discovered that the stream had run dry, and naturally there was no water wherewith to work it! As to the ram not working without an air-vessel, it would probably beat, but would deliver little or nothing, and with regard to the question of frost, he would ask Mr. Easton to reply, as he had had a much greater experience in installing rams.

Mr. Easton stated it was found that when the ram was put into a pit, and covered over with a wooden cover, it kept running during frosty weather; there was no trouble in that respect.

With regard to the question of the pollution of the drinking water from the impure source by which it was driven, it would be observed that in the compound ram there were two small holes, just over the bottom piston, and below the upper one, through which any polluted water could escape, so that no mingling of the two streams past the upper piston was possible.

Home Textile Experts Visit India

Many of our readers will be interested to learn that Mr. Geo. T. Barrett and Mr. Robert Bridge, two of the Directors of Messrs. Brooks & Doxey (1920) Ltd., the well-known firm of Lancashire Textile Machinists, arrived at Bombay last month, and will be located at the Taj Mahal Hotel until the end of January.

Mr. Barrett has been in close touch with all the developments of the textile industry for a considerable number of years. After serving for some time with Messrs. Howard & Bullough, he was with the firm of Messrs. Tweedales & Smalley for 25 years, and, as their Home representative, played an important part in the development of their business in the British market. This experience, coupled with his long service in the machine shops of both firms, places him in a very special position to discuss all matters affecting cotton spinning from a practical standpoint.

During the last half-century, Messrs. Brooks & Doxey have supplied a considerable portion of the spinning machinery used in India and have completely equipped many important cotton mills.

Motor Passenger Vehicles on Railways

In many countries trials are being carried out in order to determine whether it is not possible to find a cheaper means than that afforded by the ordinary train, of meeting passenger travel requirements on railways in sparsely populated districts. Much has been done in this way in Great Britain, and quite recently the North Eastern Railway converted a Leyland motor-bus from road to railway use. Their experience so far is that this provides a facile and cheap means of meeting traffic requirements on branch lines, and enables them to provide a better service than would economically be possible if it were necessary to run the ordinary train, and it is probable that this method of working will be extended. Similarly, in France, recent trials carried out in the Bordeaux district have shown that where traffic is comparatively light a 60 h.p. motor in a four-ton car can haul two ten-ton coaches at speeds up to 50 km. per hour on comparatively level standard gauge tracks, with a reduction of five to ten francs per km. in working costs as compared with steam. The French Minister of Public Works is encouraging these experiments, and it is stated that he has invited the Prefects of all Departments to inquire into the practicability of using petrol motor traction on the Departmental lines, which are really light railways running alongside the country roads.

OUR NEXT ISSUE

will contain a

SPECIAL REPORT

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MANCHESTER TEXTILE EXHIBITION

Low Head Water Turbines

IT is not by any means generally known that water turbines are in regular use to-day, giving highly efficient results when working with very low heads.

This means that the water turbine replaces the old-fashioned water wheel, and there are many plants at work all over the world operated by these low head water turbines giving highly satisfactory results.

Properly regarded, there is no competition between water power on the one hand, and steam power (and the like) on the other. While it is true that this is a matter of relative costs, in a general way wherever water power is available, it is the first choice. It is frequently more economical to develop the water power, and if it is not sufficient, then consideration of the alternative begins, and a choice of auxiliary prime-movers is open. In some existing plants, the fuel-burning steam, gas or oil engines may have been installed, without proper consideration of water power resources, and here the tendency is to explore every means of obtaining all possible assistance from the installation of modern turbines, and to put the existing steam plant out of commission as much as can be arranged.

As an instance of this latter tendency, we refer readers to the illustration on page 324, showing a water-driven pumping set. This comprises two independent water turbines working under a *maximum* fall of 4 ft. 6 in., direct-coupled to two duplex double acting force pumps, of a combined capacity of 90,000 gallons per hour against a total head of 210 feet. At the water-works where this set is fixed, all the pumping possible is done by water-power. When this is not at its maximum, the turbines are still kept in commission, but the stroke of the pumps (which is readily adjustable) is altered to maintain speed. The turbines are designed to give good efficiency even when the potential head is reduced by flood, and will continue to give good results even with only one foot fall. This plant was designed and manufactured by Messrs. J. J. Armfield & Co. Ltd., London, the turbines being their "River" patent type. The low-head high-capacity machine has now been brought to a very satisfactory point, rendering streams useful which it was impossible to harness successfully before. This turbine is of high power in comparison with its size, rendering it a cheap unit, while its high specific-speed runner makes it most suitable for the generating of electricity. The "River" patent turbine can often be direct-coupled where otherwise losses would occur in the transmission necessary to obtain a sufficiently high speed for the generators.

The above example is, of course, only one of many such installations, but gives an interesting insight into the field which is open for the low head turbine. Where water is available at any head, it is well worth while to get into touch with the makers of modern water turbines, to obtain the benefit of their experience whereby maximum power may be obtained from a given fall and volume of water, and it is rather surprising what economies may be effected to-day by considering the most recent developments along these lines, when such a natural source of power is at hand. We emphasise this point because not only are standard types of machines available, but we understand from the firm referred to above, that they are prepared to build a machine to suit individual requirements, the fact which under certain circumstances may be a matter of very vital importance as regards efficiency.

A Book about Sweden (*Continued from page* 354)

the educational system and social conditions in Sweden, partly illustrated with diagrams of railway and telephone statistics, etc. Swedish achievements in sports and gymnastics are also mentioned. So far the introduction.

The main part of the book is divided into two chapters, namely, "Economic Life and Industry," and "Through Sweden." In the first of these chapters the reader is made familiar with facts and figures relating to agriculture, forestry and mining, with their adjuncts. England being a large consumer of Swedish timber, paper, iron and steel, much of interest will be found in these pages. Some figures and illustrations relating to the construction of electrical machinery will, however, probably be quite new to the average reader. As an instance may be mentioned the rotor of a 30,000 H.P. generator (illustrated on page 62), constructed by the Swedish General Electric Co. Amongst the art industries, the manufactures of china and glassware, etched and engraved steel articles, etc., are mentioned briefly, and the products of artistic handicraft are given some space. The subjects are necessarily treated concisely, but the main object of the book is to encourage travelling to and in Sweden.

The chapter "Through Sweden" is treated more comprehensively, and the illustrations are numerous. One finds that going to Sweden is both easy and comfortable, and that travelling in the country is exceptionally so. The reader is familiarised with the principal towns, the unique canal routes, and other well-known features, but besides this the book takes the reader to the wilds in Northern Sweden, which can be reached in comfort by rail. It is a characteristic of the book under review that it treats many of these out-of-the-way places all over the country, and one gets a kaleidoscopic view of forest and field, river and lake, mountain and waterfall, in an almost bewildering variety. It must, however, be borne in mind that the walnut tree grows in the oak and beech region of the South, and that the country extends in a northerly direction to the region of the dwarf birch, which rises some six inches from the ground only. Hence this variety of landscape, of which a book can give a feeble idea only.

Reviews

STEAM TURBINES. By WILLIAM J. GOUDIE, D.Sc., M.I.Mech.E., etc. Published by Messrs. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. Price 30/- net.

THIS volume is the second edition of Mr. Goudie's text-book on Steam Turbines, and although the first edition was issued so recently as February, 1917, this new edition has been practically re-written and also enlarged, a fact which indicates the very rapid progress made during recent years in the development of the steam turbine.

The volume under review covers the subject in a most detailed and complete manner, some 800 pages being devoted to the subject of steam turbines pure and simple, that is to say, the turbine itself is dealt with to the exclusion of all auxiliary plant.

Each different type of turbine is considered in detail, and special chapters are devoted to such sections as The Properties of Steam, Nozzles, Blading, Rotors, Mechanical Reduction Gears, Governing, etc. Special attention is drawn to the peculiar value of the steam turbine for those industries where steam is required for heating and process work, in addition to that required for power, a steam turbine working under such conditions being an ideal machine. In fact, exhaust steam is supplied automatically for heating requirements in accordance with the demands of the factory.

Although this publication has been designed primarily for the steam student, it is obviously a text-book which should be in the hands of every engineer who is in any way associated with steam either on the manufacturing or running side.

The following very brief summary of the chapters in the second edition compiled by the author gives some idea of the ground covered by this new publication.

The introductory Chapter I is the same as that of the first edition.

The descriptive Chapters, II, III, and IV, dealing respectively with impulse, reaction, and combination turbines, have been re-written, and contain illustrated descriptions of recent designs by leading makers.

On account of the rapid development of the geared marine turbine within the past few years, the descriptive section on marine turbines has been recast and enlarged to form Chapter V.

This descriptive matter is prefaced by a short account of the development of turbo-propulsion.

The properties of steam are dealt with in Chapter VI, which has been entirely re-written on the basis of Callendar's characteristic equations and steam tables.

Chapter VII, on energy diagrams, has been revised, and numerical examples have been calculated in conformity with the Callendar equations and steam tables.

Chapter VIII, on nozzles, has been slightly enlarged. A section on the Hϕ diagram, modified to take account of supersaturation, has been added.

The ordinary and modified Hϕ diagrams, together with two serviceable monograms for calculation of total heat and specific volume of superheated and supersaturated steam, are given on sheets in the pocket of the book.

New worked examples have been added.

Chapter IX, dealing with blading, has been revised and extended.

Chapter X, on rotors, has been revised, and a new section dealing with the critical speeds of rotors supported on three or more bearings has been added, with a graphical solution of a three-bearing case.

Chapter XI is new, and deals with the subject of mechanical reduction gears, with special reference to marine turbines.

As the technical literature on the subject is scanty, it is hoped that the discussion in the chapter may be found serviceable by marine engineers.

Chapter XII, on mechanical losses, has been revised, and new worked examples have been added.

Chapter XIII, dealing with the condition curve, reheat factor, internal efficiency and efficiency ratio, has been completely recast, and a new method, which is applied to provisional design calculations in the later chapters, has been developed.

Chapter XIV, on steam consumption, has been re-written and brought up to date. A section on feed-heating by means of steam tapped from the turbine has been added, together with new worked examples.

Chapter XV, on the provisional design of impulse turbines, has been re-written, and new methods of calculation have been developed. Their application is illustrated by several provisional designs.

Chapter XVI, on the provisional design of reaction turbines, has been revised. More up-to-date designs have been substituted for those in the first edition.

Chapter XVII, on the provisional design of the Ljungström turbine, has been revised and a new design has been added.

The descriptive Chapter XVIII, on governing, has been recast and brought in line with recent practice on land and marine turbines.

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"A BOOK ABOUT SWEDEN."—Published by the Sweden Traffic Association.

SUCH is the title of a small volume, issued by the Swedish Traffic Association, an organisation whose principal object is to stimulate touring in Sweden. The book, however, covers a very much wider field than a guide book of the predominant type. It provides an introduction to the history and politics, industrial conditions, scientific and literary activities, and state of culture in general of the Swedish people, finishing up with an illustrated travellers' guide.

The introduction gives a short outline of geographical facts, including geognostic and statistical data, and is illustrated with maps ranging from physical geography to hydro-electric statistics and comparative density of population, etc. One also finds notes about the flora and fauna of the country. The constitution of Sweden, the history of the people and their various achievements, are briefly outlined. A chapter is also devoted to

(*Continued on page* 352.)

INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

Volume II FEBRUARY, 1923 Number 7

BETWEEN OURSELVES

We have before us a bound copy of the first volume of INDUSTRIAL INDIA, and we are amazed to find what a tiny patch of the vast field which lies before us has actually been covered during a whole year of prospecting. We are apt to overlook, in the excitement of political upheavals, the commercial conditions of a country, and to lose our perspective of its industrial progress and development. Probably the industrial progress and development of India would have been greater than it has been, had the political atmosphere been more tranquil, but, despite unsettling factors, this progress has been remarkable. We are about to publish an account of the commercial and industrial evolution of India during the last twenty-five years, and it will be found that in several vital directions conditions have completely changed. From being an agricultural country, with undeveloped resources and out-of-date methods of working, India has been slowly but surely developing into an industrial nation, despite the fact that three-fourths of her population are still employed upon agricultural pursuits.

* * *

VARIOUS causes have contributed to bring about this change. The rapid rise of Japan into a position of commercial eminence, and a careful study of the industrial history of England, America, and Germany, gradually convinced Indians that the salvation of their country lay entirely in its industrial regeneration and development. This conviction was strengthened by a report of the Indian Famine Commission, which gave as its opinion that the poverty of the people—and the risks to which they were exposed in seasons of scarcity was mainly due to the fact that agriculture formed almost the sole occupation of the great mass of the population. The Report further suggested that diversity of occupation must be introduced, so that the surplus population can be drawn from agricultural work to manufactures or some such employment. In these days of mechanical inventions and scientific progress, it is, however, much easier to talk about industrial development than to effect it, especially in a country like India, which is full of ignorance, conservatism, and poverty.

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ALTHOUGH the Government have done much to assist the growth of indigenous industries, they have not been able to do all they desired, and what industries are now at work are almost entirely controlled by Europeans, and nearly 85 per cent. of the capital employed comes from companies registered in London. This, in the present mood of the Indians, is directly opposed to their most cherished ambitions. They desire to see India a manufacturing, as well as an agricultural country, and for such manufactures to be maintained by Indian, and not by European capital. The decay of old industries, and the creation of new tastes and habits, have built up a demand for foreign articles which Indians are becoming desirous of supplying for themselves. How far they will be able to succeed with their ambitions and aims is at present problematical. Let us, however, briefly review some of the leading industries now at work in India, and mark the progress which has already been made.

* * *

THE question of transport, important in all countries, is especially important in India. Owing to the vast distances to be traversed, and the inefficient facilities existing, transport is at present one of the greatest hindrances to Indian industrial development. To quote the words of a Government Report in recent years this "is a matter of the gravest concern." The defence which the railway authorities make is the one of expense. They point to the fact that the returns show a great decrease in receipts as compared with the estimates: from 1st April, 1920, to 20th May last year, for example, the returns fell short of the estimated receipts by 208 lacs of rupees. This was due to a falling off in both passenger and freight receipts, which was in turn due to a lack of sufficient rolling stock. The local authorities state that the capacity of existing workshops in India is very limited, and that their output is dependent upon the supply of wheels, axles, and brake gear from England. We ask why on earth this should be? Surely, after seventy years of railway work and experience, it ought to be possible for India to manufacture its own rolling stock. An engine which cost £3,910 in England before the war now costs £8,300, while the price of a four-wheeled wagon has increased from £210 to £780. Has it never dawned upon the railway authorities that the wisest—and, in the end, the cheapest—policy would be to spend the money, now spent on importing material, and paying heavy freight charges, in developing local supplies, and training men in India? It is not because Indian labour is inefficient, or that Indians fail to take interest in railway work, as is borne out by the fact that at the present time 733,152 Indians, out of a total number

of 751,752, are employed in railway work. It is, we fear, a question of a short-sighted policy which fails to see the possibilities of a situation.

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LET us now take a look at the coal industry. A pamphlet published just prior to the war by the International Geological Congress in Canada states that the coal deposits of India amount to 79,001,000,000 tons, which is more than the combined deposits of Russia, Japan, Persia, Spain, Manchuria, and Korea. Yet, despite these vast deposits, the total production of coal in India in 1920 excluding what is mined by the miners for their own use (some 350,000 tons) was only 17,962,000 tons, which is not only 20.6 per cent., or 4,666,000 tons less than the output in 1919, but is also far below the average *per capita* output of other countries, and worked out at only 94.4 tons per head of the number of workpeople employed, as against 184 tons in Great Britain, 803 tons in the United States, and 122 tons per head in Japan. Although these figures reveal a decrease in production, capitalists are still firm believers in the possibilities of the trade, as is evidenced by the fact that the capital employed therein has steadily risen from Rs. 722 lacs in 1911-12 to Rs. 937 lacs in 1920-21, while the number of joint stock companies interested increased in the same period from 128 to 256. India is capable of supplying a very large amount of the total coal demand of the world; yet at the present time she does not supply 4 per cent. of the world's output of coal. To sum up the present position of the Indian coal industry: there are vast stores of wealth lying idle because of our antiquated methods of mining, our out-of-date machinery, and our unskilled and indolent workers. The world offers a great and wealthy market for our exports, but at the moment India is not even supplying her own internal needs.

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THE timber industry is another glaring example of our contention. The whole world is suffering from a timber shortage, and India is able to supply not only all the needs of the whole British Empire, but the needs of many other countries as well. Yet India actually imports every year large quantities of timber in 1920-21 the amount sent in from Japan alone amounted to 62,382 tons. The forests of India cover an area of 240,000 square miles, and added to this there is a further area of 12,468 square miles under the control of the Forests Department; but up to now the commercial side of the industry has been neglected. Despite this, however, the forest lands produce a gross annual revenue of over 2½ crores of rupees, and a nett surplus, after deducting all working expenses, of 1¼ crores of rupees. The annual average production during the five years 1914-15 to 1918-19 was 387,603,348 cubic feet, but the authorities themselves admit that these figures could have been easily doubled perhaps trebled had more intensive and systematic forest management been employed.

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TURNING to the great staple industry agriculture. Recent Government statistics show that out of 621 million acres of land in British India only two-thirds is under cultivation. Out of a total of 388,375,000 acres available for cultivation, *i.e.*, 63 per cent. of the total acreage in British India the aggregate amount under tillage is 222,825,000 acres, or 36 per cent. of the total area. Of the remaining 27 per cent. that could have been cultivated, 18 per cent. was not even taken up, while 9 per cent. was intentionally kept fallow. If the whole available acreage were put under cultivation, famine would be reduced by over one-half, and probably even more, if new methods were introduced, for the present yield per acre in India is, to say the least, very poor. In Bombay and the United Provinces the yield of wheat per acre is only 1,250 lb., as compared with 1,973 lb. per acre in the United Kingdom, and 2,874 lb. in Belgium, while even in rocky Switzerland the yield is 1,858 lb. per acre. The average yield of barley per acre in the United Provinces was 1,300 lb., as against 2,105 lb. in the United Kingdom, 2,953 lb. in Belgium, and 2,198 lb. in Switzerland. Even the average yield of rice per acre in India is only half of what it is in Japan. Not only is much land going to waste then, but even the land under cultivation is worked in anything but a scientific manner. Fields are only ploughed very shallow, they are either badly manured, or not manured at all, irrigation is totally neglected, or else carried out in a very imperfect and inefficient manner, and even when seed is purchased it is of such an inferior quality that its productive force is very small. It is estimated that if the intensive methods of cultivation which prevail in Japan and Holland were employed in India, agricultural production could be increased by at least 50 per cent.

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TAKE again the Indian sugar industry. The average production of sugar per acre in Java is 4 tons, and in Hawaii 4½ tons, whereas in India it is only 1 ton. There is a larger area under sugar in India than in any other country in the world the area being half the aggregate acreage yet the normal output is only one-fourth of the world's cane sugar. Recent results obtained from selected strains of cane show that an average yield of 6,800 lb. per acre of raw sugar is possible, as compared with the normal yield of 4,000 lb.

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WE have said enough to reveal a very unsatisfactory state of things existing in India to-day regarding what may be called her "greater" industries, the production and output from which are undeniably much below what they ought, and could easily be made, to be. The same remarks unfortunately apply to what may be called (at present) the "lesser" industries. For example, copper which was at one time obtained and smelted from ore found in Southern India, Rajputana, and the Himalayas, and which, with enterprise and modern methods, could still be profitably worked. Nay, we go further, and question whether India might not become the greatest copper producing nation in the world. Instead of which, the industry has become practically extinct, and the annual average value of copper imported during the five years 1914-18 was just over £800,000. The corresponding figures for brass were £517,000. We could go on, if space permitted, piling example upon example, but enough, we think, has been said to prove the unsatisfactory condition of most of the Indian industries, and to justify the policy of INDUSTRIAL INDIA, which is "to support and record any movement which seeks to encourage the development of India's resources and industries."

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IN speaking recently upon the present unsatisfactory condition of Indian trade and industry, the British Trade Commissioner remarked: "There are only two remedies open. India must either perfect her own organisation, discard her old ideas and methods, and make a bid for trade in a manner in keeping with the times, or she must

relinquish the business. Up to date the sole efforts seem to have been directed to appeals to the Government —through the different Chambers of Commerce—for restrictions upon foreign competition, so that the country might still go on undisturbed in the old inefficient, haphazard way." India has been spoon-fed long enough, and if she wishes to take her place among the industrial nations of the world, she must first of all realise the keenness of the competition which is being carried on against her, and then strain every nerve, use every method, and employ every new machine to increase the output of her existing enterprises and launch out upon an energetic campaign to revive her old and almost extinct industries. India must either "go on, or go under," and which she does, depends entirely upon herself.

* * *

WE would like here to deal with a side issue which relates in every sense to the problem we have been discussing. We have said in effect that the commercial prosperity of India and we may here include Ceylon—depends not only upon the success of what we may term the major industries, but also upon the minor industries which are conducted throughout the length and breadth of the country, and in many cases in the homes of the people. In short, the "cottage industries" call for special help and consideration. Our Government and municipal authorities should do all in their power to foster these industries. This has not always been the case, and reports recently to hand from Ceylon give an illustration of their neglect. When the plumbago in Ceylon failed, nearly 150,000 workpeople were thrown out of employment. The majority of them aided by local merchants took to manufacturing tea chests for the export tea trade, and, up to a few months ago, a large industry was being carried on, the men securing employment as sawyers, transport workers, and makers of the cases. Not only did this industry save the men from the misery of unemployment, but the Government itself derived a considerable revenue from transport, freight charges, dock and harbour dues, and so forth. During recent months, however, the Japanese have become keen competitors, and, as a consequence, the local industry is threatened with extinction. In their efforts to capture the market, Japanese manufacturers have been selling at considerably under cost, and as the Japanese goods are allowed to enter Ceylon free of duty, local makers have been working under a serious handicap. Much of the local work is done in the homes of the people, and the locally made boxes can be undoubtably sold at a very cheap rate; but, low as this price is, the Japanese are selling cheaper, and the local makers are consequently in despair. A few months ago an influential deputation of the Ceylon manufacturers waited upon the Finance Committee of the Government, and pointed out the serious condition in which the industry finds itself, and requested that an import duty should be levied upon the Japanese goods. Such a tax would still permit of Japanese goods being sold at advantageous prices in competition with the local products, but it would save the local industry from extinction, and, by saving it, would secure the existing revenue from this source for the Government, who, otherwise, will be compelled to find fresh means of taxation, and, moreover, it would prevent a large number of people from being thrown out of employment. We have not yet seen the reply of the Government, but hope that something practicable will be done to preserve this industry for our splendid little island.

Centrifugal Steel Castings

A demonstration was given at the Iron and Steel Institute meeting, held recently at York, by Mr. William McConway, of Pittsburgh, U.S.A., of his new mechanical process of steel casting, intended especially for productions such as tyre blanks and turbine discs, by centrifugal methods direct from the molten steel. This process may result in a complete revolution in the handling of steel from the molten condition to the finished product, and has been six years in course of perfection. In the case of tyre blanks, for example, by the ordinary process there is, as is well known, an enormous loss in metal in the form of scrap, and the great advantage of this new centrifugal process is that the amount is reduced to less than 5 per cent. Mr. McConway claims also that the direct handling of molten steel by centrifugal means will enable us to produce the cheapest forms of rolled steel, such as bars for ferro-concrete work, from centrifugally cast billets, and the blooming mill will become a thing of the past.

The "McConway" centrifugal casting machine consists essentially of a horizontal cylinder in which the castings are made, fitted with a piston, and having a hydraulic cylinder at the other end of the machine. The molten steel is poured from a ladle through the runner into the casting cylinder or mould, using a detachable casting head, the cylinder revolving at a peripheral speed of 65 feet a second. The molten metal is at once thrown by centrifugal force to the periphery of the casting cylinder, and forms a cylindrical or ring-shaped casting, according to the mould used. The casting cylinder is fitted with a cast-iron liner, and the piston has a cast-iron face, so that the actual casting takes place in cast iron. In the particular machines most in use, the diameter of the cylinder inside the liner is 30 inches, and the length of the cylinder 12 inches. As soon as all the molten steel has been poured, the piston is slowly advanced, and the steel casting as it cools is compressed from 12 inches to about 10½ inches. The whole process takes, say, a quarter of an hour, about 10 to 12 minutes being for pouring, revolving, and solidifying, and 5 minutes in removing to the soaking pit. The hydraulic end of the machine to operate the piston works, as a rule, at 500 lb. per square inch, and the difficulty of making a tight joint at this pressure when in rapid revolution has been got over by the invention of a special form of stuffing box. The finished steel casting is easily ejected, because of the much greater shrinkage of cast steel as compared with cast iron, of which, as already seen, the casting cylinder is composed. When the steel casting is discharged from the machine, it is taken to a soaking pit and finished off under a hydraulic press.

INDUSTRIES

Conducted by FRANK DAWSON.

THIS MONTH WE ARE FEATURING A SPECIAL REPORT OF THE TEXTILE MACHINERY EXHIBITION, MANCHESTER, 1922

Some Notable Exhibits at the Textile Machinery Exhibition, Manchester

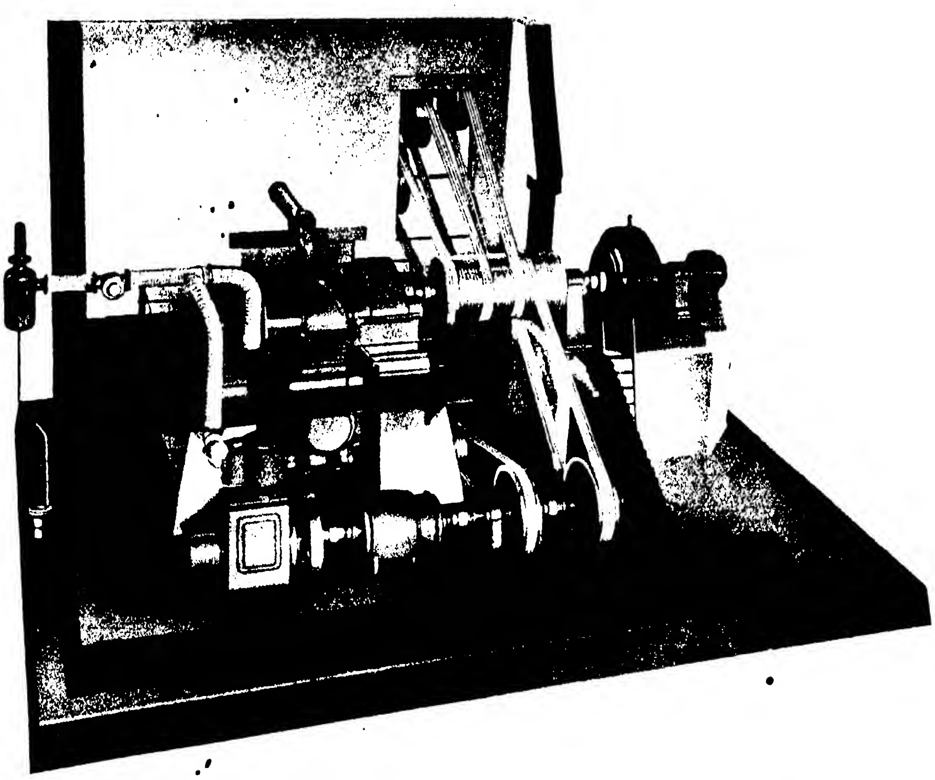
THE above Exhibition cannot claim to have represented the textile industry, as many of the well-known British makers were not represented. Otherwise, the Exhibition was a most interesting and instructive collection of machines and auxiliaries relating to the textile industry.

There were a large number of exhibits devoted to machinery for the manufacture of knitted underwear, and a visitor rather got the impression that such machines largely made up the Exhibition.

Space will not admit of trying to deal with many of the interesting features, so we have selected the following as giving some indication of the progress made in this industry, and as revealed at the Manchester Exhibition.

Metropolitan-Vickers Electrical Co. Ltd.

The question of the most efficient means of driving textile mills is again



Model of a Steam Turbine specially designed for Textile Mill Drive

Metropolitan-Vickers Electrical Co. Ltd.

receiving the attention of both mill owners and engineers.

Many alternative methods are available when designing a new mill that cannot be considered in the case of existing mills. There is, for instance, much to be said for electrification either by "group" or "individual" drive in many cases. In others, the arrangement of the mill is such that a purely mechanical drive is the best and sometimes a combination of mechanical and electrical drive presents the most efficient solution to the problem. Of mechanical drives we have a large variety of engines from which to choose, but since reduction gears have been brought to such a high state of perfection (notably in connection with ship propulsion), the steam turbine has assumed a paramount position.

Illustrated on page 358 is a working model of a steam turbine mechanical drive specially designed for textile mills, and readily adaptable to existing mills. This model was exhibited by the Metropolitan-Vickers Electrical Co. Ltd., of Trafford Park. As will be seen from the illustration, the engine room of a mill is depicted equipped with a high-speed steam turbine, totally enclosed reduction gears, and rope wheel driving the shafting on the various floors of the mill. If it is desired to provide electric light or to drive remote portions of the mill electrically, a generator could be coupled to an extension of the rope wheel shaft. This generator (which could be either alternating or direct current) is, of course, an optional portion of the plant, and could be either in the same engine room as the turbine or in an adjoining room, as shown in the model.

The steam turbine is an engine which possesses the property of utilising a high vacuum far more efficiently than can be done by a reciprocating engine. In order to avoid loss of vacuum between the turbine and the condenser, it is very desirable that the latter should be placed as near to the former as possible. The best position, therefore, for the condenser is immediately below the turbine exhaust. Hitherto this has entailed a basement of considerable depth, or a total height from condenser floor level to engine room ceiling greater than can usually be afforded in existing mills. The Metropolitan-Vickers Company, however, have given great consideration to this point, and in the installation shown the total height from basement to ceiling is only about 15 feet. The

Klincha Belt Lacing Machine — W. T. Nicholson & Clipper Co. Ltd.

Company are making these machines in sizes varying from about 800 b.h.p. to 2,000 b.h.p., which is a range that should cover the requirements of most textile mills.

Some remarkable efficiencies can be guaranteed with this new machine. The actual steam consumption of the machine would, of course, depend upon the steam pressure, superheat, etc., but as an example we may say that for a turbine of 1,500 h.p., this firm is prepared to guarantee that the steam consumption will not exceed 10 lb. per b.h.p. hour, with steam at 180 lb. pressure, superheated 180 deg. F., with a vacuum of 28½ in. Note that this per brake horse-power is equivalent to, say, 9 lb. per indicated horse-power on a steam engine.

The model shows a condenser of the low level multi-jet type, in which the steam and injection water are intimately mixed, but a surface condenser could, of course, be supplied if desired.

The condenser pumps are normally driven by ropes from the main turbine, and a small steam engine is provided for driving these until the turbine is up to speed, after which the engine is cut out by means of a clutch. If electricity is always available for starting purposes, a small motor could be used instead of this engine. In the arrangement shown in the model, a small D.C. generator is also supplied, which can be driven by the engine or from the main turbine, two clutches being provided, one between the engine and dynamo, and the other between the dynamo and the rope wheel. This should prove exceedingly valuable for pilot lighting and when overhauls and repairs are being done throughout the mill at week-ends and holiday times. The main turbine is such that, if desired, it can be made suitable for passing out a quantity of low-pressure steam for heating the mill or drying, boiling, etc.

Where there is a demand for steam at a pressure of 20-30 lb. for any of these purposes, such a proposition makes a very economical installation, as it takes very little more heat to raise steam to a pressure of 180 lb. than it does to raise low pressure steam at 30 or 60 lb. for heating. On the other hand, steam in expanding

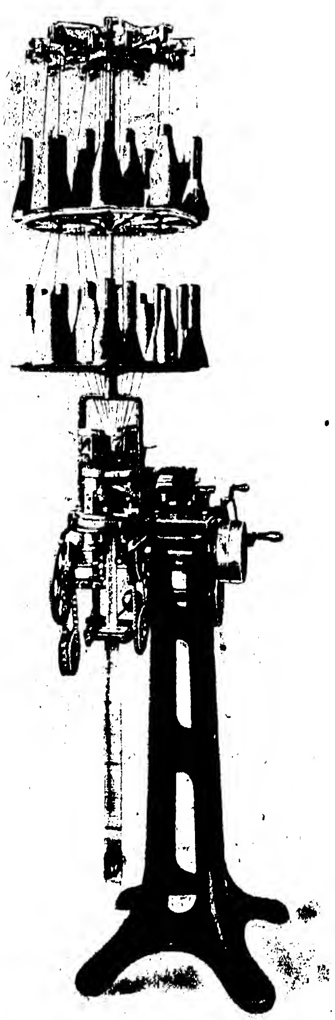
from 180 lb. to, say, 30 lb., can be made to do a lot of useful work in passing through the turbine.

W. T. Nicholson & Clipper Co. Ltd.

This firm exhibited their " Klincha" belt-lacing tools and fasteners. The principle of this fastener is that a series of wire hooks are attached to each belt end, and after bringing the two ends together, a pin is passed through the two sets of hooks, after the manner of a door hinge.

A special machine is provided for fastening the wire hooks to the belt, and these hooks are specially prepared. One of the features of this arrangement is the speed with which a belt may be repaired. The firm claim that a 3 in. belt can be joined up in one minute, and the operation is a very simple one; any labourer can perform it with efficiency.

Another claim is flexibility, and that the fastener will run round the smallest pulley without noise. The fastener is certainly a very business-like and practical arrangement.



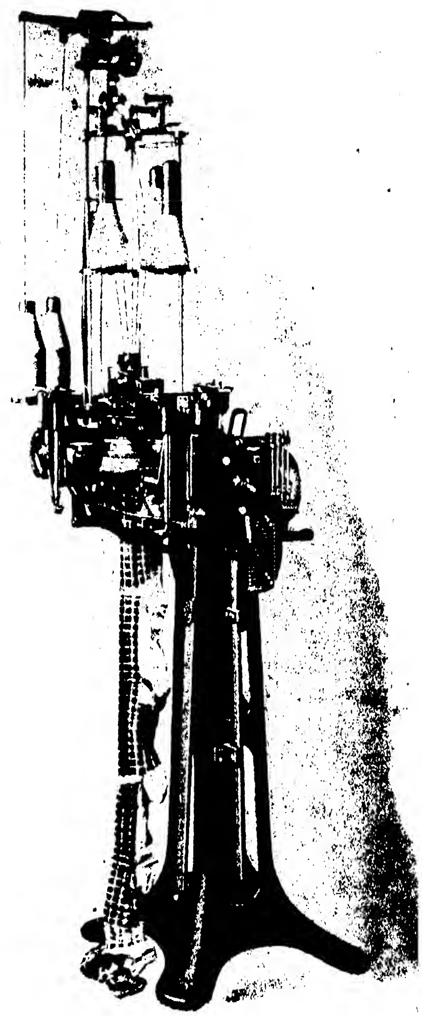
Model 3 Necktie Machine *Wildt & Co. Ltd.*

Wildt & Co. Ltd.

Included in this firm's interesting exhibit were the three following machines.

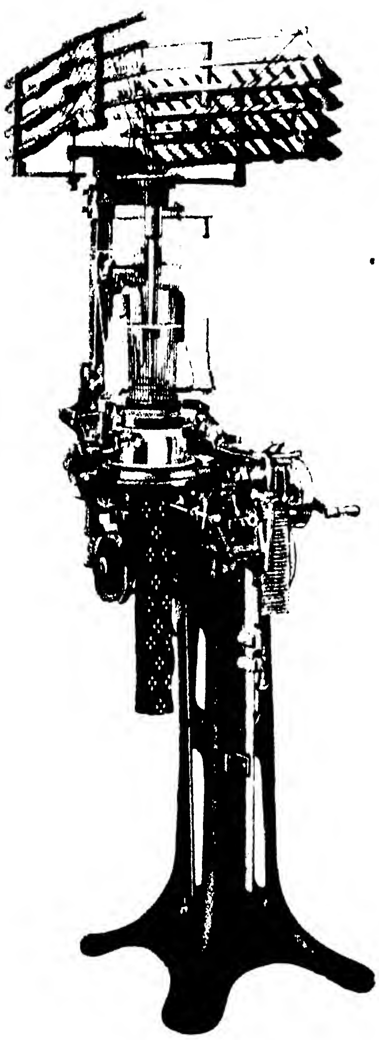
The " George " vertical striper for fancy seamless hose and half-hose, which produces solid vertical stripes, checks, spots, and zig-zag effects. The original, or ground thread, is knitted continuously on all the needles as on a plain machine, and the patterning threads are superimposed, being laid additionally in the needles by means of special guides which can be put out of action at any desired course or courses, and, apart from thus making a continuous or broken vertical stripe, it can also be shogged laterally over a predetermined number of needles, so that various forms of zig-zag effects are possible. A very wide range of patterns can be made on this machine, which is constructed in all diameters from 2¼ in. to 4 in., and in all gauges. It is entirely automatic in all its actions, and on ladies' hose runs continuously, passing from one hose to the other without any attention on the part of the operator. In the manufacture of half-hose it is also automatic as far as the knitting goes, but it must stop at the end of each foot, so that the other cylinder may be inserted in the machine. On half-hose the rib top is run on to the needles of one cylinder whilst the other cylinder is knitting, as on the Plain George machine. The gauge of the machine may be changed by substituting other cylinders, either finer or coarser, together with the dial for the striping feeders. The length of the hose is governed by a measuring chain, and may be altered by removing or inserting links. The production varies according to the gauge, number of needles, pattern, yarn, etc., and the average production is 15 to 18 dozen pairs of half-hose per week of 48 hours.

The " George " Model B machine is for fancy hose and half-hose, and is a distinct advancement on anything which has been done previously in the fancy seamless trade. By means of a newly-created innovation in the development of certain camming arrangements, this machine gives an extensive range of patterns, *e.g.*, tartans, checks, spot effects, squares, rectangles, and many combinations of plain and broken stripes, both horizontal and vertical, and other effects. Whatever the pattern, the machine produces a plain self-foot (spliced) of any desired strength consistent with the gauge of the machine, which is constructed in all diameters from 2¼ in. to 4 in., and in all gauges.



" George " Model B *Wildt & Co. Ltd.*

The Model 3 necktie machine is constructed in 2 in. and 2¼ in. diameter, with 49 needles to 99 needles in the cylinder. That is to say, the finest gauge is 16 needles per inch. The machine has two feeders, six coloured striping apparatus to each feeder, two sectional pattern wheels, and automatic drawing off motion. The machine will make all complicated tucks, etc., as it has two sets of cams working on independent butts of needles. Eight different kinds of



"George" Vertical Striper — *Wildt & Co. Ltd.*

needles can be employed in the cambox, needles with single and double butts, high single and low double butts, and long and short latches. In addition, the machine has two sectional design wheels, which for maximum scope are equipped with interchangeable bits held in position by segmentary plates; with these design wheels, in conjunction with the needles, an unlimited variety of designs may be obtained; striping, diagonals, fancy spots, and plaited design and tuck patterns. In addition to the six colour latchguard, in place of the four colour on the Model 2 (thus rendering possible neckties containing six colours in all), it has also independent racking of the striping and tucking drums respectively. These movements are controlled independently from the chain, so that on each course over the full length of the necktie, as regards the striping or barring, the colour to be inserted can be predetermined. Likewise, within the limitations of the pattern wheels, the tucking effects can also be varied at will. These actions are quite independent, and are not confined to the repeat of the drum as in the case of the Model 2. To cope with a large number of colours, this machine possesses a double-decker bobbin stand to take 48 bobbins, *i.e.*, 4 bobbins to each of the 12 fingers on the machine. Automatic change from design to plain for the neck band is regulated by the chain. There is a special slackening cam for the neck band, and the machine possesses adjustable stitch cams. It is equally well suited to work real silk, artificial silk, mercerised cotton or plaiting with these various threads. The same construction is used in 7 in., 9 in., 14 in. and 20 in. diameter, for making scarves, etc.

S. Noton & Sons

The cop paste apparatus and utensils exhibited by this firm are for the purpose of securing a uniform thickness of cop paste, and to do away with the unnecessary labour involved in carrying the paste from where it is mixed to the different spinning-rooms.

These machines have had a long trial, and have proved satisfactory in every way. They are essential to all spinners using paste, and as many machines have been in use constantly for over twenty years, they have secured for themselves a well-deserved reputation for reliability.

The illustration shows one of the double cylinder systems, with a 60-gallon mixing pan and an 85-gallon supply pan coupled up to pipes.

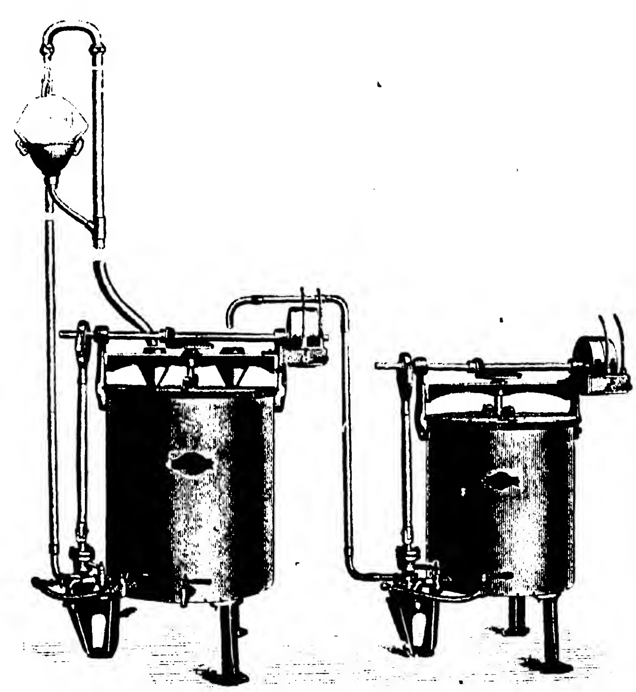
The paste is first boiled and mixed in the mixing pan. It can then be pumped to the supply pan; or, as an alternative method, the mixing pan can be fixed to a stillage of sufficient height to allow the paste to flow from the mixing pan to the supply pan.

The paste is then pumped from the supply pan through the feed pipe to the various spinning rooms. On this pipe a branch is fitted in each room with a self-closing tap, and an enamel basin fixed underneath to catch the surplus paste.

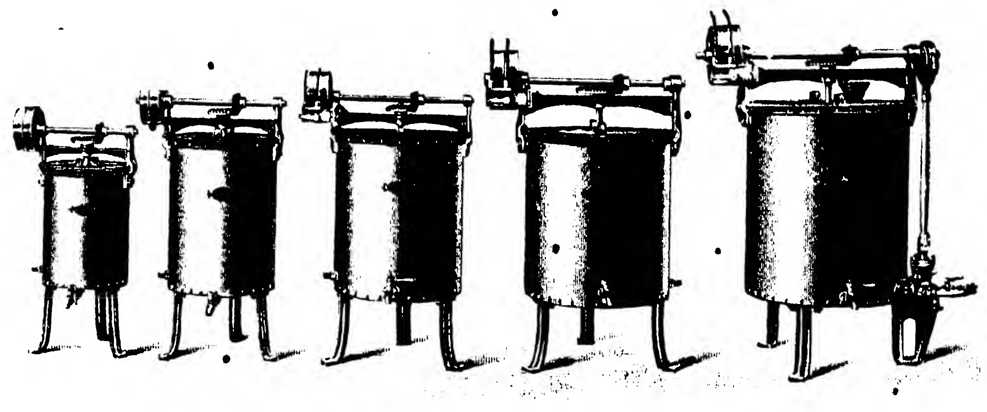
A bend is fitted at the end of the feed-pipe to the top room; this connects it to the return pipe. The latter is of a larger diameter, and is conducted back to the machine in the basement.

The apparatus can be used on the single cylinder system, whereby one cylinder is used for both mixing and supplying. This will be found adequate for a mill of about 80,000 spindles on up to medium counts.

Mixing machines are made in five



Cop Paste Pumping and Mixing Machine — *S. Noton & Sons*



Different Sizes of Cop Paste Mixing Machines — S. Nolan & Sons

sizes, varying from 14 gallons (sufficient for six pairs of mules) up to 85 gallons (sufficient for thirty six to forty pairs of mules).

For those cotton spinning firms who appreciate the necessity of a continuous supply of clean cop paste, without waste of labour, these machines will be found indispensable.

Greenwood & Batley Ltd.

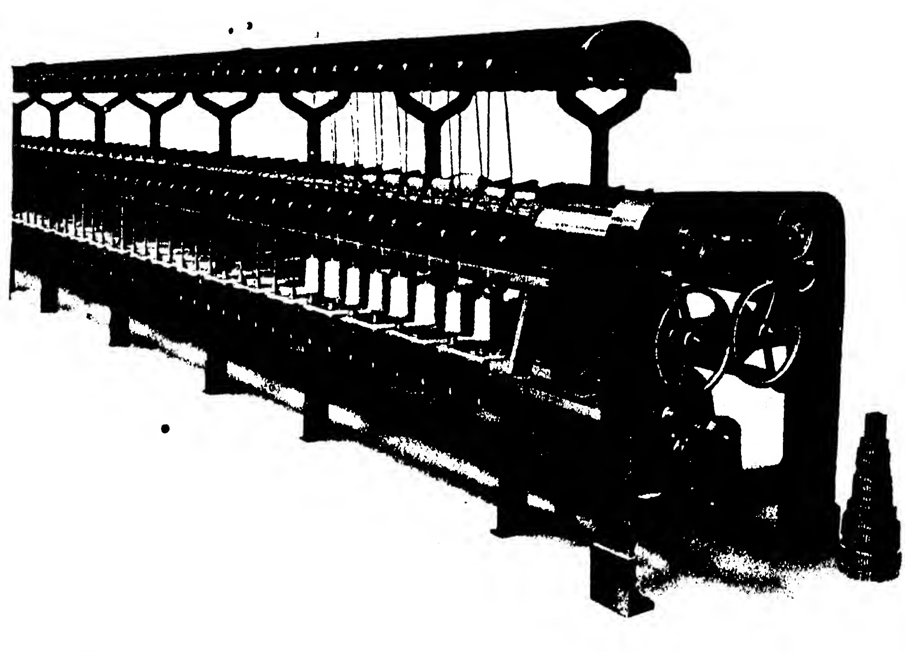
The exhibits of this firm included the following two machines: -

(1) "Climax" patent combined twisting and winding frame, for the twisting or doubling of any classes of yarn of two or more ends, with any pre-determined number of turns per inch twist, and the winding of the resultant twisted yarn in cheese form on to tubes or double flanged bobbins, in one operation. Also suitable for putting extra twist into single yarns. Machine designed to work all classes of yarn, including cotton, wool and worsted, flax, net silk, spun silk, artificial silk, jute, ramie, etc.

Special features of this machine are as follows: Elimination of one process in the usual routine of twisting two or more fold yarns. Large economies in labour, power consumption, floor space, bobbins, and general upkeep required. High spindle speed, with consequent large production. Impossibility of occurrence of "single." Individual doffing to each spindle. Perfectly cylindrical cheese and regular twist. No travellers, flyers, or loose rollers. No ballooning or lashing. No grease-marked yarn.

(2) "Climax" patent cheese or cone winding frame, for winding wool, worsted, cotton, silk, or any other fibrous yarns from spinning bobbins, cops, or other forms of supply, on to cheeses or cones, 5 in. traverse or more if required.

Special features of this machine are as follows: Patent weighted car-



Climax Patent Combined Twister and Winder — Greenwood & Batley Ltd.

riages, with steadying motion, which ensure perfectly round cheeses or cones with maximum length in each wound package. Improved stop motion, for up to six ends per drum. Patent dead-weight disc tension motion, ensuring an equal tension on each individual end in winding. Special breaking-up motion on traverse, so that two ends are never laid exactly over each other, and so preventing lacing during winding. Improved double cam traverse motion, giving positive quick return at each end of traverse, thereby preventing overlashing at ends of cheeses or cones. Special facility for changing driving pulley to alter the speed of the drum shafts on headstock.

(3) Squirrel cage protected type induction motor, 3 h.p., 400 volts, three-phase, 50 cycles, 950 r.p.m., with slide bed and pulley.

"Igranic" Star Delta starter, fitted with one no-voltage and two overload releases.

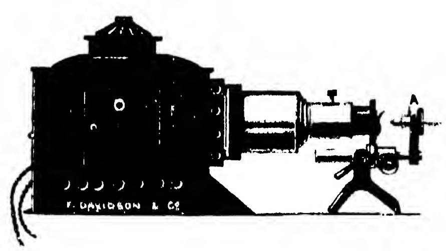
F. Davidson & Co.

The Manchester agent of this firm, Mr. Geoffrey Wollaston, gave us a very lucid demonstration of the firm's micro telescope. This apparatus is a combination of microscope and telescope, and it would appear to be an important new development in aiding man to more closely examine detail.

The combination of "field" and "depth of focus" made possible by this apparatus is truly remarkable. It is well known that when a high-power object-piece is used in an ordinary microscope, that both field and depth are extremely limited, and therefore the object to be examined must be specially prepared. In the Davidson apparatus, however, this is not necessary, and to look through the eye-piece of this apparatus at any ordinary, unprepared object, is to see such object as with the human eye, but, in addition, to see it magnified many times, according to the lenses used.

The scope for this new apparatus is very evident, and it may also be combined with a projector, or used for photographic purposes.

Our illustration shows the "Davon" micro projector, which comprises a lantern body with a 4 in. condenser, and a supplemental condenser which takes the place of the ordinary projecting objective. The body tube of the microscope is removed, and an adaptor to carry a microscope objective is substituted. The Abbé rim of the microscope slides over the end of the supplemental condenser. The illuminant may be either a "pointolite" or an arc. The supplemental condenser is focussed to bring a point of light on the specimen to be projected, and the focussing wheel of the microscope is employed to focus the image on the screen. In this simple way most effective microprojection can be done, and objectives up to $\frac{1}{8}$ in. may be used with complete satisfaction.



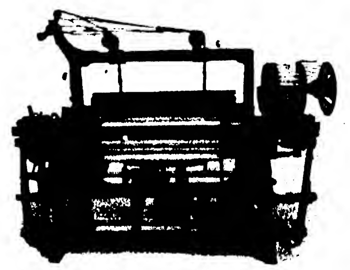
Davon Micro Projector

F. Davidson & Co

The British Northrop Loom Co. Ltd.

The products of this well-known firm were well represented as follows:

The "T" model loom is the standard narrow cotton loom for weaving from 2 to 6-shafts inside treading, or for dobby or jacquards. The loom on the stand was weaving a 4-shaft twill shirting. It carries the usual Northrop motion for automatically supplying weft without stopping the loom, M. & P. automatic warp stop motion, and Roper automatic warp let-off motion.



T Model Northrop Loom

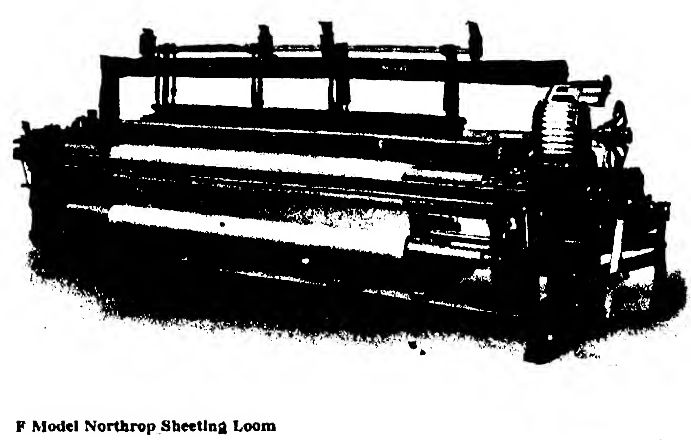
The battery will accommodate 24 cops or bobbins, equal to about $2\frac{1}{2}$ hours' supply on 24s weft. A bobbin is transferred from this battery whilst the loom is running at full speed, and the weft threads up into the shuttle automatically.

The automatic warp stop motion, which is of the M. & P. type, stops the loom immediately a warp end breaks, and consequently avoids faulty pieces being made in the cloth. It also permits the weaver to be away from a loom for an indefinite period—this being necessary when a large number of looms are being attended to by one weaver.

The automatic warp let-off motion automatically regulates the tension and let off of the warp from beginning to end, only one setting being required, and this is of a very simple nature.

The feeler, which controls the motion that renews the supply of weft, is of the latest side-sweep type, and it reduces the waste weft to less than 1 per cent.

The Lacey top motion is applied for making positive the action of the heald tappets. This keeps all healds equidistant, and can readily be con-



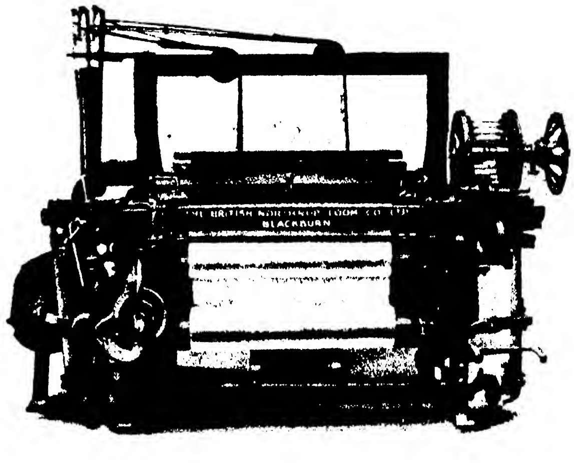
F Model Northrop Sheeting Loom

verted to work two, three, four, five or six healds.

The cloth take-up motion is of the positive type, with ratchet wheel movement, and a simple crank, or thin-place-preventer, which operates to let-back the cloth whenever the weft fork operates.

The cloth wind-up is of the Northrop spring type, which allows the cloth to be removed without stopping the loom. Up to twenty-four looms of this type are being attended to by one weaver in Lancashire to-day.

The "H" Model loom is specially designed for weaving fustian cloths. It has a stronger frame, slay and back-rest than the "T" Model, and is fitted with a positive outside plate tappet which may be arranged to operate up to twelve heald staves. Also, it has a cloth take-up motion which is actuated by a worm, to enable high numbers of picks per inch to be inserted in the cloth. This loom is fitted with the usual automatic battery carrying cop weft. It has also an automatic warp stop motion of the No. 4 type. The warp let-off motion, however, is of the ordinary friction type, with weights and levers.



H Model Northrop Fustian Loom

The cloth wind up is of the friction type, which assists in the subsequent operation of fustian cutting by winding up the cloth without flattening out the weft.

The workmanship in this loom is of a very high standard. All gears (including bevel gears) are machine-cut, with the standard rolling pitch, which constitutes the finest contour known to engineers.

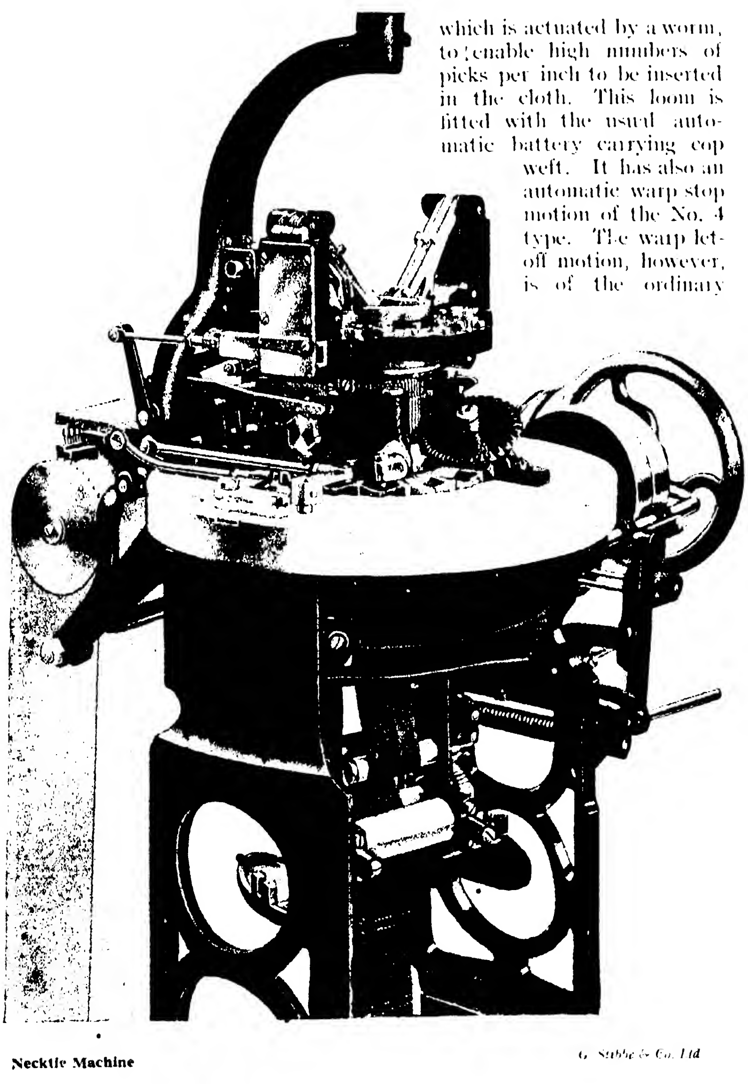
The crankshaft is ground to exact size, both as regards diameter and the angular position of the cranks. This ensures perfectly uniform and parallel movement to the slay, and is of very considerable assistance to the true running of the shuttle.

The temples, battery, and tappet plates, are also ground true to ensure correct movement and a minimum of friction.

The "F" Model sheeting loom carries the standard battery for automatically replenishing the weft, also the M. & P. automatic warp stop motion, as on the "T" Model.

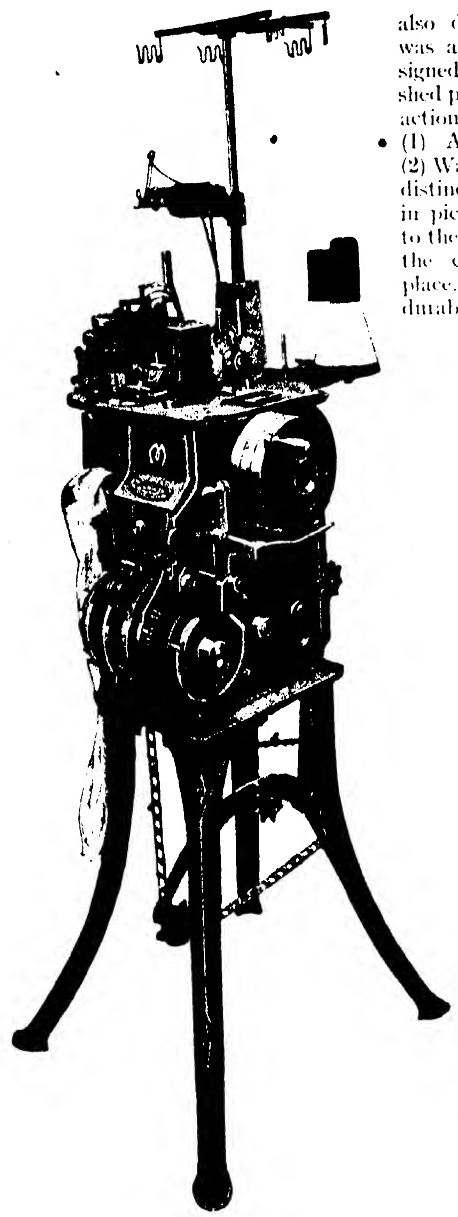
The Bartlett automatic warp let-off motion contains a unique arrangement in the differential motion, which enables the warp beam to be in two separate parts, but maintains equal tension on the two parts, even though one section is full and the other nearly empty.

The drive is by friction clutch and pinion, and is especially good for broad and heavy looms of this type. The motor is kept running continuously, and the clutch may be engaged by means of the starting handle to start the loom. A switch enables the motor to be stopped whenever a new warp is being gaited, or for



Necktie Machine

G. Stibbe & Co. Ltd



"Maxim" Tipper *G. Stibbe & Co. Ltd.*

similar lengthened stoppages. The finish of this loom is the same as on the "H" Model, and represents the highest standard in the making of looms.

All crankshafts, tappet-shafts, and swing or rocking shafts are bushed, and loom frames are milled to exact dimensions.

The slays and slay-caps are made of selected ash, with race-boards of maple, which ensures the greatest strength and durability.

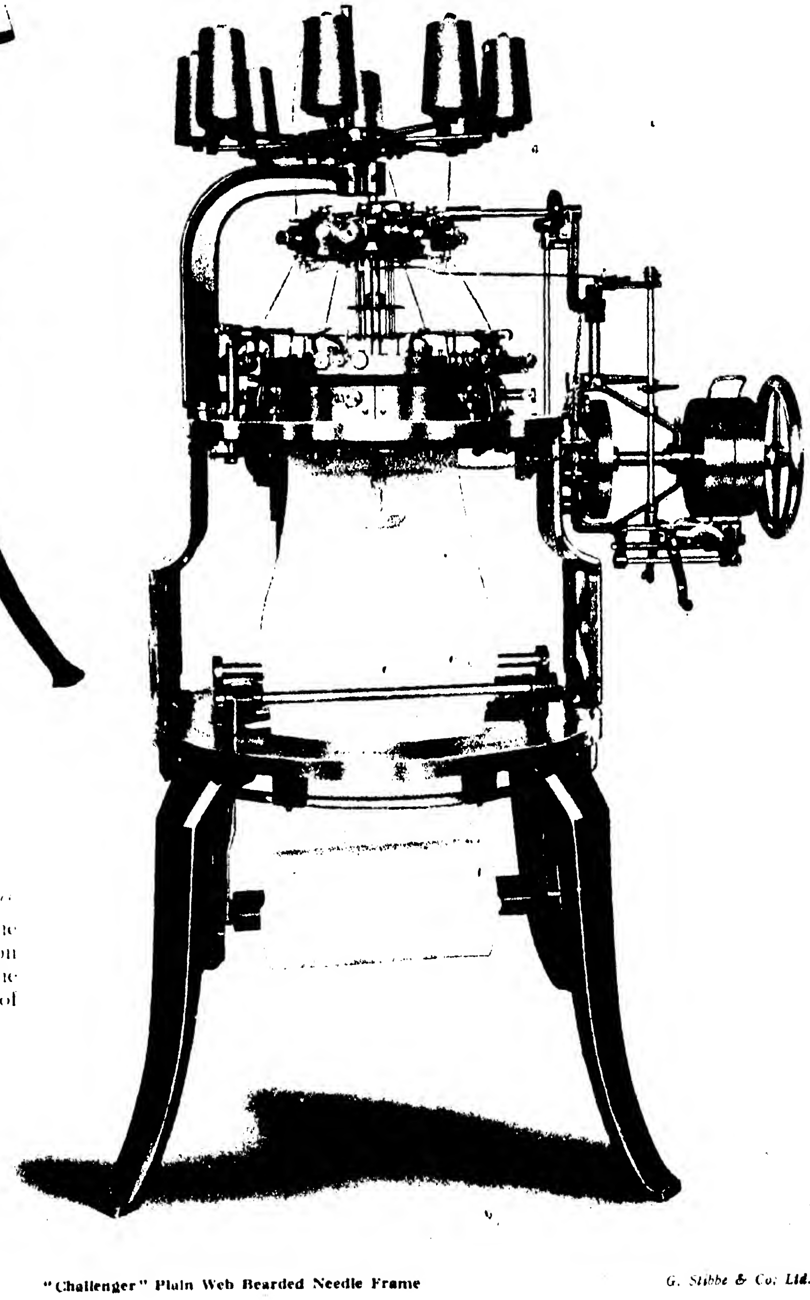
In addition to the three looms mentioned, a Leeming dobby was also displayed. The dobby shown was a 16-shaft dobby, specially designed for heavy work. It is an open-shed positive dobby, and is circular in action. Its special points of merit are: (1) Absolute certainty of shedding. (2) Warp ends pass each other at three distinct levels. (3) Extreme simplicity in pick finding. (4) Being connected to the cloth take-up motion, it reverses the cloth when pick finding takes place. (5) Broad bearings with great durability.

All gears are cut, and essential shafts hardened and ground.

The shed has one third of a pick dwell, which enables plain cloth to be woven to advantage, and "cover" obtained the same as with tappet-shedding.

G. Stibbe & Co. Ltd.

We illustrate three of the machines exhibited by this firm for making knitted underwear.



"Challenger" Plain Web Bearded Needle Frame *G. Stibbe & Co. Ltd.*

The plain Challenger (F.B.S.S.), of the bearded needle type, with measuring wheels, is the latest development of the plain webber. It is built on the same lines and in the same factory as the Challenger (F.B.S.) latch needle machine.

The needle is of the same form and design as the firm's regular cylinder needle, except that it has the beard instead of the latch.

The stitch formation is as near to that of the straight bar, full fashioned frames as is possible on a circular frame, and consists of sinking, pressing, landing, knocking-over and clearing. The needles being vertical and parallel, a true gauge of fabric, proportionate to the gauge of the frame, is obtained.

The advantages of the bearded needle over the latch needle on fine gauges are well known, not the least important being the facility with which a *good fine* bearded needle can be obtained, compared with latch needles.

On all fine gauges from 16 needles per inch upwards, this firm strongly recommend the new bearded needle frame, which can be built up to 34 needles per inch.

On coarser gauges the manufacturer has the option of the "F.B.W." or the "F.B." types. The main advantages of the "F.B.W." latch needle type are that it is somewhat simpler, and therefore costs less. Also, where the bearded needle frame is not known, users would probably be well advised to keep to the latch needle type.

Several improvements of great value have been embodied in the new "F.B.S.S." machine, notably: Sectional sinker dial, combined hole and bunch stop motion, and simple swing-back yarn guides.

The "Maxim" seamless automatic machine is intended for the manufacture of all classes of seamless hose and half-hose, and is claimed to be the first practical machine with revolving cylinder.

The cams being stationary, it has been possible to give them great solidity, and, in consequence, to build the machine upon a very solid basis, and eliminate the numerous disadvantages and imperfections that are inevitable when all the vital mechanism of the machine has to revolve at a great speed.

The "Maxim" is built in all diameters from 2 in. to 4½ in., rising ¼ in. They are built from as coarse as three needles to the inch up to 26 needles to the inch, the finest machines being 3½ in. diameter with 280 needles.

The machines of 2 in. to 3¼ in. diameter are fitted with four yarn change levers, whereas those on 3½ in. diameter and upwards have five levers, unless otherwise ordered.

The machine is likewise fitted with an appliance for splicing the ankle and sole, and with automatic slackening in those parts, by which means the loops of the instep retain their normal length, whereas the loop of the sole slackened in order to admit the splicing thread.

The perfected appliance for retaining the yarns controlled by the yarn change levers is simple in construction and positive in action.

The firm's necktie machine embodies a revolving cylinder, the bobbins and all mechanism remaining stationary. All the controls are on a single function mechanism, and the pattern mechanism is a paper jacquard, which can be quickly removed and replaced.

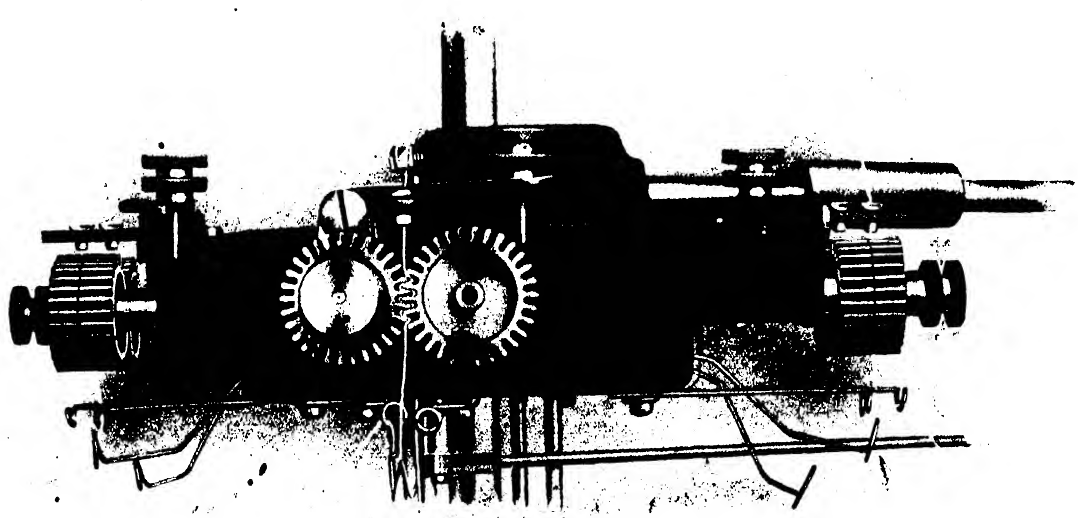
Francis Shaw & Co. Ltd.

Some very interesting temperature controlling and recording instruments were exhibited by this firm, and illustrate how the old rule-of-thumb method of judging the temperature of the liquid in many textile processes is now giving way to exact methods of measurement.

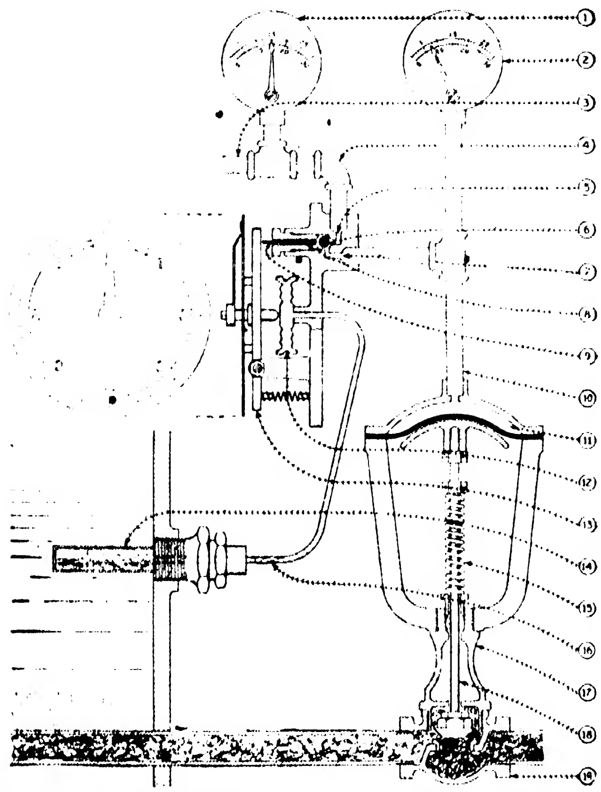
The following is a brief description of the "Tagliabue" temperature controller:

The diagrammatic view shows a typical application of a (direct-acting) Tag controller of the most widely used form (with direct-acting diaphragm-motor valve), which application will give a good general idea of how Tag controllers work, and emphasise the uncomplicated structural features responsible for the high reputation of all Tag automatic controllers.

A thermostatic bulb (14), which feels the heat, is (usually) partly filled with an easily vaporisable liquid, and is provided with a flexible connecting tube (16) which transmits the vapour pressure generated by temperature effects at bulb (14) to a capsular spring (12) which is provided with a flexible top that moves up or down in response to the internal fluid pressure, thus actuating a transmitting



Automatic Compensating Measuring Wheels *G. Stibbe & Co. Ltd.*



Diagrammatic View of Tagliabue

Francis Shaw & Co. Ltd.

lever (13), which is held against the capsular spring (12) by spring pressure as shown. The transmitting lever (13) translates the motion of the flexible top of the capsular spring (12) to an air-valve stem (8), which contacts with an air-valve ball (6), that allows all, a part of, or none of the compressed air pressure, supplied through an air-supply connection (3) to close throttle or open the steam valve by means of a diaphragm top, and as covered in detail later.

The compressed air reaches the air valve through an air-supply line (4), and through an air-supply port (5), and enters underneath the air-valve ball (6); if latter is allowed by the air-valve stem (8) to be lifted from its lower seat, the air pressure is communicated through a controlled-air port (7) and through a controlled-air line (10) to the air-operated steam valve.

That the proper amount (15 lb.) of air pressure required is available is shown by an air-supply gauge (1), while a controlled-air gauge (2) indicates the extent to which the steam valve is throttled, or whether latter is wide open or dead shut, and as exemplified later. If the air-valve stem (8) holds the air air-valve ball (6) against its lower seat, no further air pressure is communicated to the controlled-air line (10), and any compressed air previously therein escapes through an air outlet (9), latter being simply a hole larger than the air-valve stem (8). The controlled-air line (10) connects to the air-operated steam valve mentioned and designated as a diaphragm-motor valve (17), which is partly or entirely closed by the building up of air pressure in a diaphragm chamber (11), the upper half of which is formed by a metal dome and the lower half by a reinforced-rubber diaphragm, against which a so-called saucer rests, latter being connected to a steam-valve stem (18), which is surrounded by a steam-valve spring (15), thus enabling air pressure to open and close the steam valve (19).

Our Frontispiece

Mr. Ronald Wilfred Matthews, who, at the age of thirty-seven, has been elected Master-Cutler of Sheffield, is the youngest holder of that office in the long history of the Company. Mr. Matthews is deputy-chairman and one of the managing directors of Turton Bros. & Matthews (Lim.), of Neepsend Works, Sheffield, of which company his father is the chairman. He is also chairman and managing director of the allied business of J. P. Skinner & Co. (Lim.), spring manufacturers. He was educated at Cheam School, at Eton, and in Switzerland and Germany. He "joined up" soon after the outbreak of the war, and saw active service in Belgium and France, in the 5th (King's Own) Yorkshire Light Infantry, retiring with the rank of captain. Mr. Matthews' family has been associated for many years with Sheffield's staple trades, and his grandfather, William Anthony Matthews, filled the positions of Mayor of Sheffield and Master-Cutler concurrently in the year 1853. The business of Turton Bros. & Matthews was established in the early sixties by two brothers Turton. Mr. Thomas Bright Matthews, uncle of the Master-Cutler, joined the firm in 1871, and some years later the Master-Cutler's father became a partner. The original products of the works were crucible steel and files, but later the manufacture of heavy coil springs for railway rolling stock, guns, and general purposes was taken up. The business was converted into a private limited company in 1898. In the present year the company acquired the business of J. P. Skinner & Co., who specialise in making all classes of light springs.

Some Industrial Notes

Molybdenum Steels

Mr. C. N. Dawe, Chief Metallurgical Engineer to the Studebaker Motor Car Corporation, read an interesting paper on the subject of molybdenum steels a short time ago before the American Society of Automotive Engineers. The Studebaker Company have had a most extensive experience with molybdenum steels, and, in fact, have used over 2,000 tons of various mixtures in the manufacture of motor car parts, such as transmission gears and shafts, rear axle shafts, steering knuckles and pins, and driving pinions, fitted in over 50,000 cars. Unexpected results of the greatest value to the science of steel and of alloys are given in the paper. For example, as showing the intricacy of the question, after a prolonged experience it was discovered that a steel containing 0.30 to 0.40% molybdenum, 1.00% chromium, and over 0.30% carbon, is not suitable for water quenching, because of the formation of cracks, whereas a steel of almost similar composition with a carbon content between 0.23 to 0.30%, chromium 0.70 to 0.90%, and molybdenum 0.30 to 0.40%, is quite satisfactory.

There is no question that chrome molybdenum steel is of great value for heat treated parts in the automobile industry, whilst it is considerably cheaper than chrome vanadium steel, together with the additional advantage that molybdenum can be obtained in practically unlimited quantities. It forges very well, and, when properly made, cold shears as easily as other grades of steel, and it responds extremely well to heat treatment operations, practically every piece answering to the Brinnell hardness test without difficulty, whilst it machines as well as any other steel.

Molybdenum steel has also been found to possess numerous advantages in the manufacture of case hardened gears. As showing again the extraordinary effect that slight differences in composition have upon the properties of a steel, a given product of 0.190% carbon, 0.540% manganese, sulphur 0.010%, phosphorus 0.025%, chromium 0.700%, and molybdenum 0.370%, when heated, for case hardening, for 3 minutes at 1,425 deg. F. in a lead pot, gave a satisfactory product when quenched in oil, but if heated for 4 minutes under otherwise identical conditions, the product is much too brittle and practically useless. It was discovered that in comparison with the usual chrome-nickel steel, chrome molybdenum steel will result in a given depth of case hardening in 10% less time, and have at the same time an increase in shore hardness. It is the opinion of Mr. Dawe, also, that although chrome-nickel steel is almost universally used for case hardening of important parts, nickel molybdenum steel will be a formidable rival. The Studebaker Company use, with great success, for gears, knuckle pins, etc., a nickel-molybdenum steel of carbon 0.130%, manganese 0.380%, sulphur 0.022%, phosphorus 0.020%, nickel 1.580%, and molybdenum 0.20%, and they find it to be superior to chrome-nickel steel for case hardening, because of its property of hardening in oil in the hot rolled condition after carbonising, and because of its greater hardness.

* * *

The World's Oil Supply

Attention has been drawn again in America to the recent statement made by Mr. David White, the Chief Geologist of the United States Geological Survey, with regard to the very serious position of the world's oil supply, especially from the point of view of the United States.

There is no doubt that we are rapidly approaching a crisis with regard to oil, although it seems to be impossible to get the world in general to realise it. During the last year or so, for example, largely because of various coal strikes throughout the world, we have had an extensive press campaign carried out on behalf of oil, in which the most reckless statements were made, such as, for instance, that coal was doomed entirely, and would be replaced by oil, quite oblivious of the elementary fact that the present oil production of the world is not sufficient to replace more than about 10 to 12 per cent. of the coal.

Mr. David White points out that American oil fields supply about 62 per cent. of the oil of the world, whilst the home consumption in America has now risen to 75 per cent., so that it is necessary to import from Mexico 115,000,000 barrels per annum. The consumption of fuel oil in America continues to increase in the most remarkable manner, with the use of over 10,000,000 motor cars, and the wholesale conversion of merchant ships to oil firing. In this latter connection the American Government is seriously alarmed, if only on account of the United States Navy, which alone takes 60,000,000 barrels per annum.

The oil reserves of the world are extremely difficult to estimate, but Mr. David White's figures in 1920, from a commercial basis, were a total reserve of about 43 billion barrels (43,000,000,000), of which 7 billion barrels are in America and Alaska, 4½ in Mexico, 11 in South America, 5¾ in Persia and Mesopotamia, 5¾ in Russia, 3 in the East Indies, and 1 in India, with various other amounts in different parts of the world. It is, of course, very difficult to say what exactly is the real commercial oil reserve of the world, and Mr. White now admits that his figure is on the conservative side, and that perhaps a better one would be 70 billion barrels, in view of the uncertainty of the reserves in Siberia, India, Arabia, and South America.

At any rate, it is evident that the world's oil supply is not going to last very long at the present consumption of about 750,000,000 barrels per annum, which is increasing rapidly. The United States Geological Survey know as much about oil as anyone, and there is no doubt that they are very seriously concerned about the position.

Mr. David White is of the opinion that it is necessary, in the interests of the human race, that much greater efficiency be adopted at once in the use of oil, and that it would be much more economical if the use of oil for steam generation was abandoned altogether, so that the "Diesel" engine could be used only, which is a much more efficient power generator. The alternatives to the oil supply of the world, suggested by Mr. White, are especially the low temperature carbonisation of coal, and the development of shale carbonisation. The world's reserves of shale are stupendous, and it is probable that there is much more fuel value in the form of shale oil in the shale deposits of the world than in the whole of the coal, lignite, and petroleum put together.

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

The Lincoln Automatic Arc Welder

TO those who have had anything to do with the directing of welding work, it is common knowledge that the human element plays an important part in the results obtained. A good operator, proud of his work, and conscientious as to his duty, can get a good electric weld with almost any type of machine in any degree suitable for delivering a working potential and current sufficient to fuse the electrode with the base metal. On the other hand, a poor operator, semi skilled, and not so conscientious, can turn out with a machine properly designed for electric welding a decidedly unsound and unreliable weld. To strike the happy medium it is necessary to train the operators in the numerous phases of his craft, instil into his mind the necessity of good workmanship, with an object towards better and more reliable welds, and to insist on the machines being purchased to be properly designed for arc welding, and not merely a generating equipment with a breaking down element in the arc circuit to get a rough approach to the proper regulation and stability of the electric arc when in operation. The tendency for manufacturers of welding equipment is to carry out the points just discussed. In some instances a further step has been taken to design automatic welding equipment for eliminating the human element as far as can be done. Since a machine is mechanical, the human element will not be entirely removed. All automatic machines are designed for certain work, and usually the work is largely of a repetition nature. This is necessary at the present time, because automatic equipment involves a higher initial outlay of capital than hand machines, and it is necessary to make full use of the equipment, in order that the manufacturer may have a reasonable opportunity to work off the extra cost over the hand machines. If a manufacturer can increase his production and decrease his labour costs, he will not only be able to market his product cheaper, but should be able to write off the initial outlay of capital in about three to five years. This will, of course, depend entirely on the quantities he can produce and dispose of.

Owing to the nature of the electric arc, and the intense heat developed at point of fusion, it is generally accepted that the arc is of little value when welding steel $\frac{1}{8}$ in. in thickness or under, assuming that hand methods are employed, and no auxiliary apparatus is brought into action to dissipate the excess heat.

The Lincoln Electric Company, of Cleveland, Ohio, U.S.A., have recently placed on the market a type of automatic electric arc welding equipment designed to overcome the difficulties hitherto experienced in welding the lighter gauge of sheet steel. At the same time, although it will find its widest field of application on metals 26 gauge to $\frac{1}{4}$ in. butt joint or $\frac{1}{2}$ in. on head seams for steel barrels, there is no reason to think it will not be a commercial success on heavier metals, for example 1 in. thick butt joints upwards.

At the time of writing this article the machine is in successful commercial operation on range boilers, steel barrels, drums, cylinders, steel kegs, and a similar type of work of a repetition nature. The machine has also been applied to automobile construction at the largest motor car concern in Detroit.

A complete welding equipment comprises a welding unit, usually a motor generator set, an automatic attachment, suitable clamps for

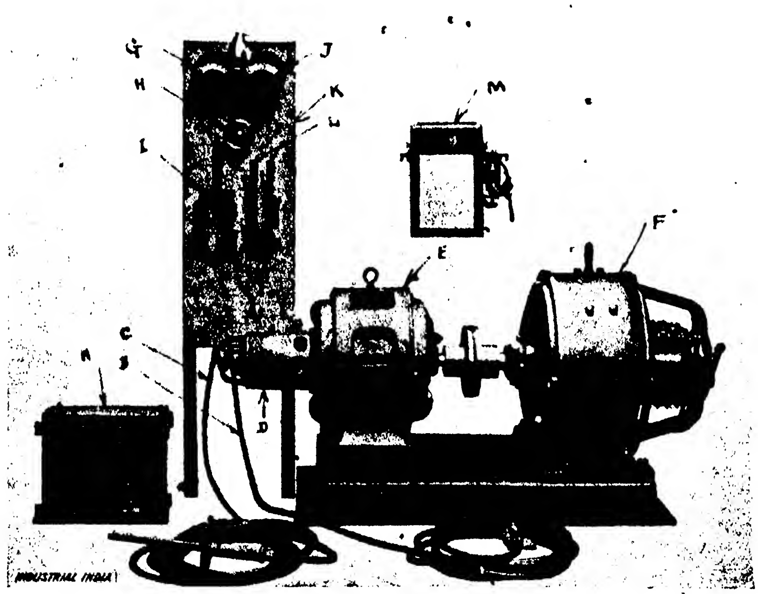


Fig. 1 400 Ampere Variable Voltage Arc Welder

holding the work, and in the case of circular objects requiring heads to be welded in a turntable apparatus.

As the Lincoln motor-generator forms part of the complete equipment, an explanation will be given of its construction and electrical characteristics.

Fig. 1 shows a four bearing set, complete with the necessary pieces of apparatus required to produce and give proper control and adjustment of the electric arc. A machine of this size, namely, 400 amperes, is capable of welding two pieces of steel butted and ½ in. in thickness, or four thicknesses of 12 gauge material stacked, the weld being made on the ends, fusing them into one homogeneous mass.

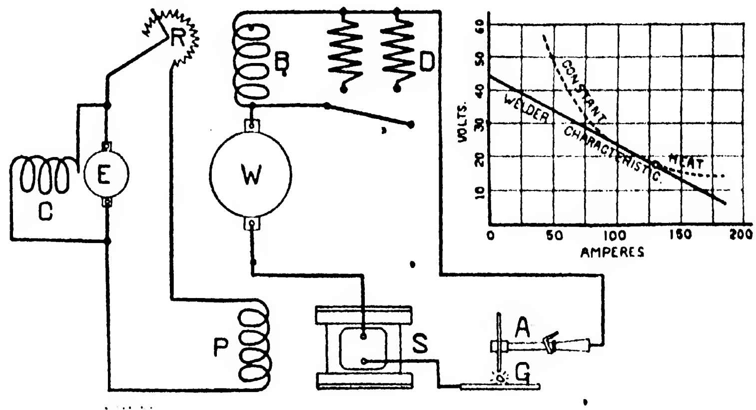


Fig. 2. Diagram of Electrical Connections of Lincoln Arc Welder, and Volt-Ampere Characteristic

(A) Electrode Holder
(B) Series Field (differential connection)
(C) Exciter Shunt Field
(D) Diverter Resistance
(E) Exciter
(G) Ground Plate
(P) Separately Excited Field
(R) Rheostat
(S) Stabilizer
(W) Welding Generator

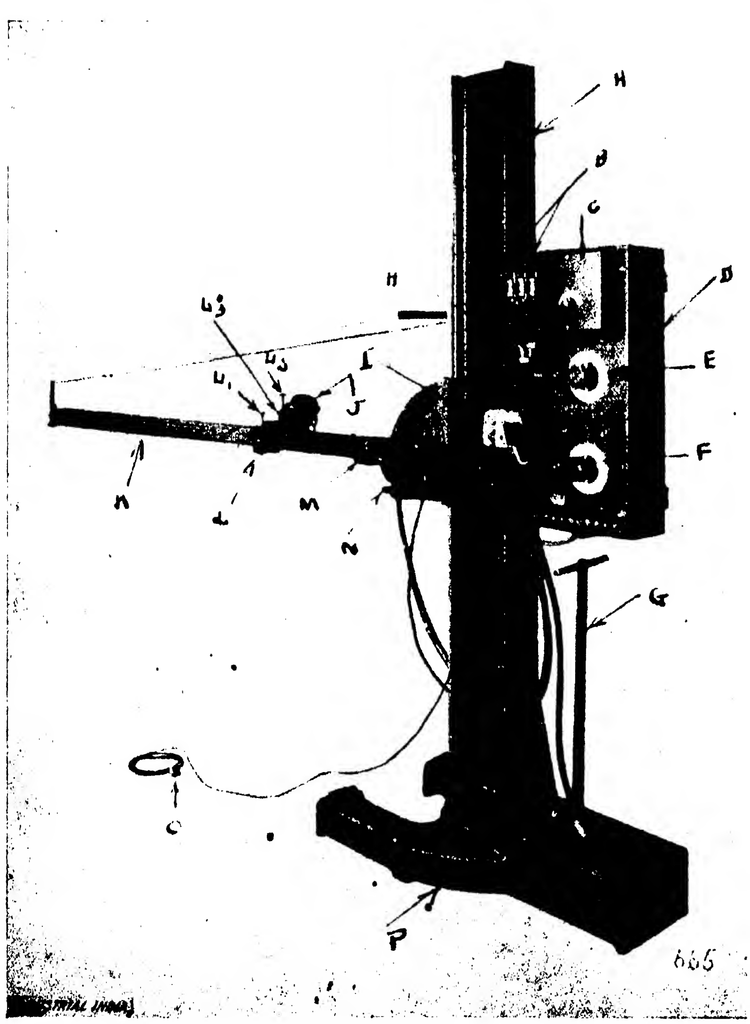


Fig. 3. Universal Automatic Attachment

A. Stabilizer.
B. Ground lead and ground plate positive terminal.
C. Electrode holder and lead negative terminal.
D. Generator exciter
E. Alternating current motor, squirrel cage, induction type.
F. Welding generator.
G. Ammeter to register welding current.
H Field rheostat for controlling excitation of welder
I. Main line double pole single throw knife switch controlling the arc circuit.
J. Voltmeter registering welding potential.
K Slate or marble switch panel.
L. Diverter switches for fixed adjustments of welding heats.
M. Auto-starter for motor equipped with no voltage release and overload relays.

Fig. 2 is a diagrammatic scheme of electrical connections of the welding generator. A curve showing the volt-ampere characteristics is also given.

The Lincoln arc welder is inherently a variable voltage machine. From the sketch it will be seen that there are two fields, one marked B and the other P. Field P is built up of a large number of turns, and in all respects resembles a shunt field. It is, however, excited by a separate source of power, instead of the field being connected across the brushes W, as is the case with a shunt field. A Lincoln welding unit will fall into one of three groups, viz., belt driven, petrol motor driven, or electric motor driven by either an alternating current or a direct current motor. In all of the above cases, with the sole exception of the last, it is necessary to employ an exciter to deliver the source of power for the separately excited field P. When direct or continuous current, as it is sometimes

called, is employed for the motor drive, the excitation for the separately excited field is obtained from the in coming power lines direct. When an exciter is employed, the separately excited field is always wound for receiving 125 volts, and the exciter obviously is designed to generate that voltage. When the motor supply is direct current, the separately excited field winding is, of course, designed for the same voltage as that of the power supply lines.

The field winding B of the variable voltage welder is a series field. It is so connected that it opposes the separately excited field P. The diverter element D is introduced as a shunt, and is designed to regulate the amount of current passing through the series field. By means, then, of the diverter switch, the amount of opposition produced by the series field may be regulated.

In operation, when running on no-load, the generator will register a voltage in the neighbourhood of 60. This is due entirely to the separately excited field winding. Upon striking an arc, the series field sets up an opposition to the original separately excited field, so that a drop in voltage is provided. The more current that is made to flow through the arc circuit, and consequently through the series field, the lower the voltage will fall. Now, since the amount of current flowing in the arc circuit depends upon the resistance of the arc, and on the resistance of the arc depends its length, it is evident that the voltage in the machine will depend upon the length of the arc, hence it is correct to say that the machine furnishes the voltage required by the arc, and that the machine has inherent regulation.

There are two ways in which the adjustment of the machine for different heat values may be made. A field rheostat (R) is introduced into the separately excited field circuit, in order to vary the strength. The same result may be accomplished by diminishing or increasing the opposing effect of the series field B. Both means of regulation are provided to give a practical range of heat values for the welding unit.

The stabilizer S, which is a continuous copper strap wound on edge around a soft iron core, is provided in series with the arc circuit to choke back the rush of current which would flow at instant of short circuit in establishing the arc. The reason that a heavy short circuit current would flow if the stabilizer were not used, is that there is a transformer action between the series field and the separately excited field, and it nullifies the opposing effect of the series field. By the use of the stabilizer, therefore, it is impossible to have such a sudden rise of current in the arc circuit, hence the transformer action referred to does not produce this effect. The stabilizer has another beneficial effect, in that once the arc is established it resists any tendency for the current field to change suddenly, thus it makes the arc easier to maintain.

The automatic machine itself is shown in the two views, Figs 3 and 4. Fig. 3 is a side view, and Fig. 4 is a view looking at the machine diagonally towards the base of the portable truck. It will be noticed, when referring to column H, that it supports the panel M and the welding arm K. A description of the parts follows:

- J. Feed motor for carbon pencil (F, Fig. 4).
- K. Welding arm.
- L. Motor bed, support for welding pencil, and adjustments for horizontal or vertical movements of welding pencil
- L_1, L_2, L_3: Refer to Fig. 4.
- M. Gear box through which adjustment of speed on L is obtained.
- N. Motor for driving L through M.
- O. Push button control for motors J and N
- P. Three wheel cast steel portable base for entire automatic features.

Fig. 4 shows a close-up view of the motors, traverse and actual means of directing the arc along the work to be welded.

- A. Crank for raising or lowering welding arm to suit different heights of work to be welded.
- B. Receptacle for holding carbon pencil.
- C. Water main conveying cooling medium to and from G.
- D. Lock nut for arm I.

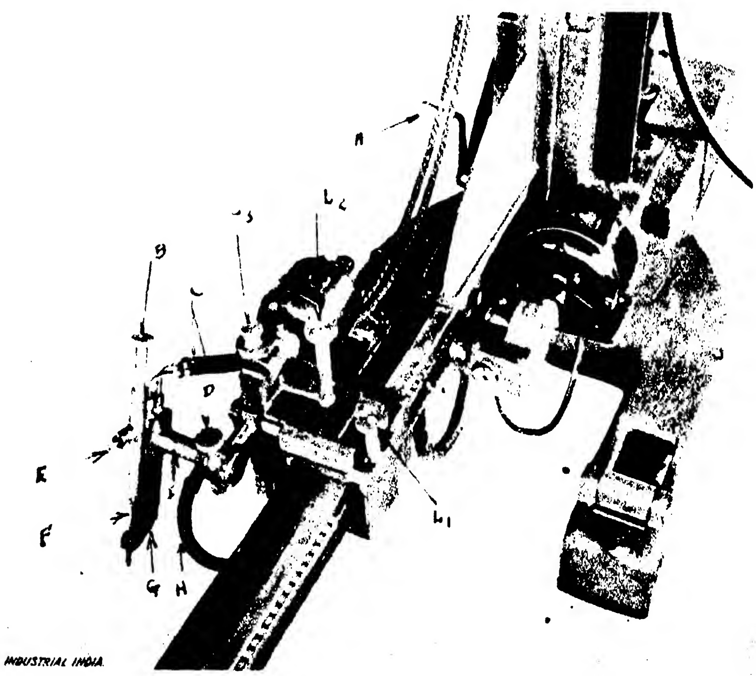


Fig. 4. Close View of Automatic Equipment

- B. Two double pole single throw knife switches and fuse protection for small motors and relays.
- C. Relay box.
- D. Switch and gear panel.
- E. Rheostat for controlling armature of motor, N.
- F. Rheostat for controlling fields of motor, N
- G. Portable truck handle.
- H. Small clapper switch through which motor (J) is started and stopped.
- I. Large clapper switch through which motor (N) is started or stopped.
- E. Lock nut for cylinder B.
- F. Carbon welding pencil.
- G. Copper current carrying terminal feeding F.
- H. Negative terminal lead from welder feeding F through I and G.
- I. Copper arm supplying G
- L_1. Adjusting nut for forward or reverse movement of carriage.
- L_2. Horizontal adjustment nut controlling side movement of welding pencil
- L_3. Vertical adjustment nut controlling up or down movement of welding pencil.

Low Temperature Carbonisation (ix)

(THE EVERARD-DAVIES PROCESS)

By DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min E., Mem. Am. Soc. M.E., A.I.Mech.E., etc.

THE "Everard-Davies" process is the invention of Mr. W. Everard Davies, of 119 Victoria Street, Westminster, London, S.W.1, and the general principle of the process may be stated essentially as a carbonisation of coal at a charge temperature of 840 1,560 deg. F. (450 850 deg. C.) in a continuous vertical retort heated externally on one side only, whilst at the same time being heated internally by a small portion of the heating gases passing through the descending charge, the externally heating combustion chambers being in three or four horizontal zones, and the retort under slight suction as usual, together with the addition of various other modifications to be described subsequently.

With regard to the principles on which the "Everard-Davies" process is based, as we have already seen, coal may be carbonised in a retort or closed vessel either by external or internal heating. The theoretical objections to external heating in low temperature carbonisation are the bad heat transmission through the thick walls of the retort (especially when made of fireclay) and the charge of the coal inside, so that a long period is required for carbonisation with a diminished throughput, one of the chief troubles of most low temperature carbonisation processes, whilst in addition 10 15% of the coal is required for carbonisation. The gas evolved, however, is of a very rich quality (700 750 B.Th.U.), and uncontaminated with any low quality gases.

The disadvantage of internal heating by means of producer or other gas is the fact that the retort has got to be of great length to get an adequate absorption of the heat and reduction of the temperature of the heating gases, which causes a considerable resistance. Also the whole of the rich gas evolved by the low temperature carbonisation is mixed with the low quality heating gases, so that the final result is a large volume of inferior and low grade gas of 120 275 B.Th.U. The advantage, however, of internal heating is that it is much more efficient than external heating, because the heating gas is in more intimate contact with the coal, of which, also, a much larger surface is exposed to the heat.

Principle of Working.

The principle of the "Everard-Davies" system is to combine external and internal heating with the object of obtaining the advantages of both. Up to 25% of the heating gases are passed through the descending charge in the retort, and it is claimed that the efficiency of internal heating from the point of view of heat transmission and absorption is so great that the addition of this amount greatly improves the throughput of the retort. Thus it is maintained that the heat transmission at 1,110 1,470 deg. F. (600 800 deg. C.) is quicker than externally heated high temperature methods at 2,000 2,250 deg. F. (1,095 1,235 deg. C.), that is, 1 inch per hour penetration of the maximum carbonising temperature. At the same time, the small volume of the internal heating gases only results in the final exit gases from the retort with, say, 32½ 40% volatile matter in the coal, being reduced in quality to 400 550 B.Th.U., so that they can be used quite easily for town's gas. The yield is given as 40 therms (4,000,000 B.Th.U., equal to, say, 8,750 cubic feet of gas at 450 B.Th.U.) per ton, and the product can also be mixed with producer or blast furnace gas for power purposes.

As already seen, the temperature of carbonisation adopted is higher than the usual low temperature figure of 930 1,110 deg. F. (500 600 deg. C.). Mr. Everard Davies is of the opinion that with his retort, because of the increased heat transmission, reduced time of carbonisation and consequent less "cracking," the temperature of carbonisation can be 1,380 1,470 deg. F. (750 800 deg. C.), whilst still retaining the gaseous and liquid products characteristic of the more usual low temperature carbonisation, although, generally speaking, 1,380 deg. F. (750 deg. C.) should be regarded as the maximum. The correct figure, however, depends on the quality of the coal, and may vary from 840 1,560 deg. F. (450 850 deg. C.).

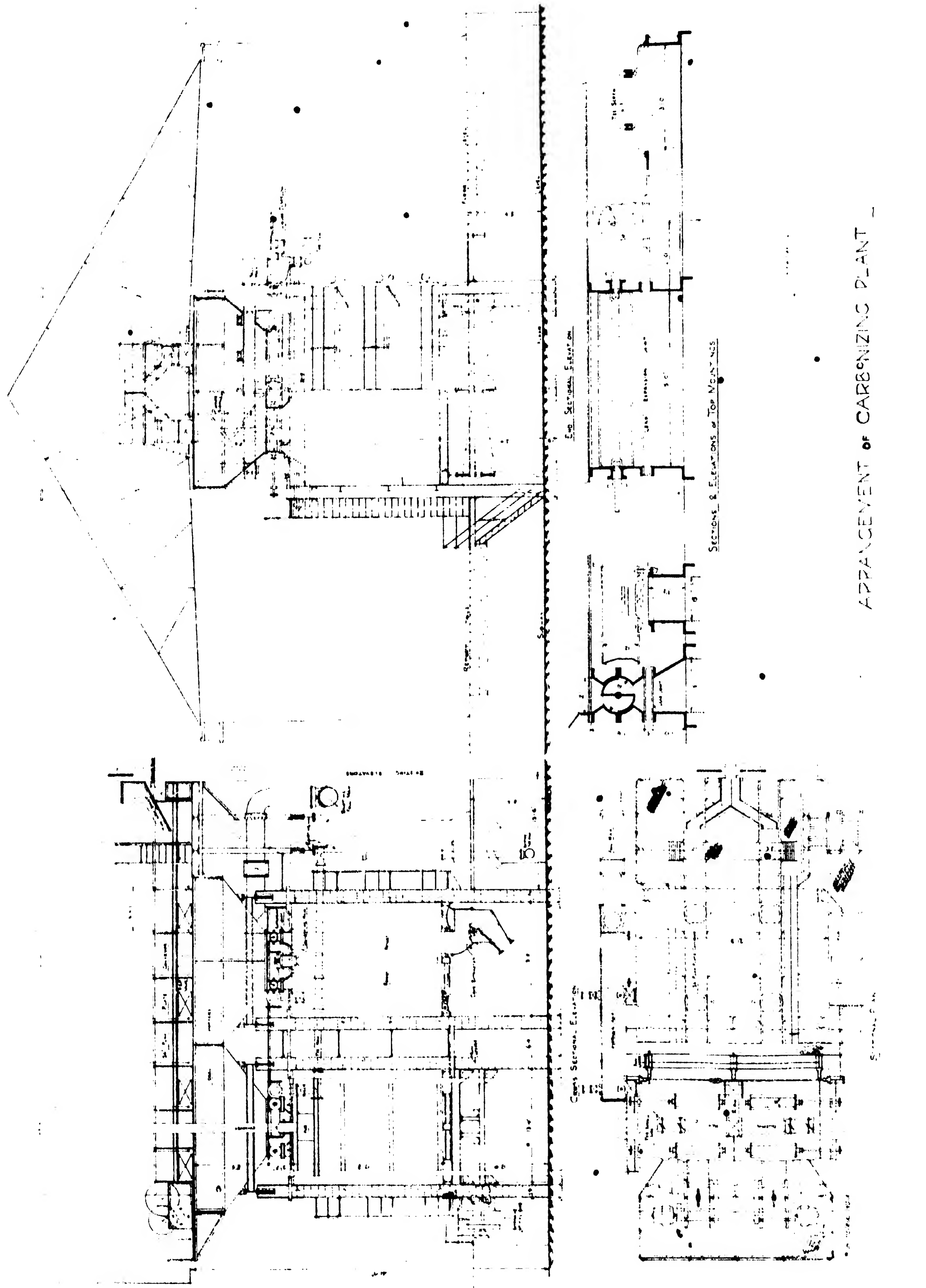
It may be stated, however, that it is the intention to work the "Everard-Davies" retort at either high, medium or low temperatures, according to circumstances, and the flexibility of the control of the temperature of both external and internal heating is claimed as one of the advantages, together with the fact that coal, lignite, or other solid fuel can be used.

Oil Yield

In any low temperature carbonisation process there are always two opposing factors, higher temperatures to increase the yield of gas and the hardness and value of the residual smokeless fuel, and lower temperatures to increase the oil yield and the value of the liquid products by the absence of cracking. The question of the percentage of the resinous constituents of the coal comes into play in this connection, and some coals, for example, will not give a satisfactory hard low temperature household fuel because the temperature is not high enough to melt the resins. This can be got over by blending coals, and also to some extent by zone carbonisation, and Mr. Everard Davies maintains that a combination of external and internal heating is the best way of reconciling the two opposing elements. In general, 70% of non-coking coal mixed with coking coal can be used.

The claim is made that this method of low temperature carbonisation obviates the difficulty of the swelling and expansion of the coal, and yet at the same time gives a hard, porous household fuel, which is of course smokeless and free burning, with the emission of radiant heat, as usual.

The swelling and frothing of coal under carbonisation generally commences at about 660 750 deg. F. (350 400 deg. C.), but it is stated that the chief difficulty with this action in externally heated retorts is that the slow heat transmission means



ARRANGEMENT OF CARBONIZING PLANT

that only 15–25% of the total time of carbonisation is available for re-solidification, and the expansion takes place in one stage and jambs the retort. In the "Everard-Davies" retort the carbonisation is in three or four zones, so that the swelling is carried out in successive stages, which makes the action much less severe, whilst the quicker heat transmission leaves 30–50% of the period of carbonisation for re-solidification, which action is aided also by the internal heating.

With regard to the quality of the residual smokeless fuel, Mr. Everard Davies' contention is that the usual 6–12% volatile matter in low temperature fuels is not high enough, and better results are obtained with 10–16%. Such a fuel is still perfectly smokeless, ignites more readily, and it is claimed that there is no difficulty in obtaining a hard porous fuel, but for such conditions the total volatile matter in the original coal must exceed 30% to give sufficient margin for by-product yields. The general idea of this theory is that the extra heat required to drive out the 4% volatile to give a produce of 6–12% instead of 10–16% is very costly, and the extra by-products are not sufficient to make a profit.

Construction

The "Everard-Davies" installation (as illustrated in Figs. 1, 2, and 3) consists of twin firebrick vertical continuous retorts, the accessories, in the way of coal feeding appliances, housing, coke withdrawal mechanism, hydraulic main, etc., being on the usual vertical retort lines, and the price of the complete equipment will be about the same as a high temperature installation for the same throughput.

Heating Arrangements

Fig. 1 is a vertical section through the fluework of the retort, the left (AA) being a section through the centre of the combustion chamber, and the right (BB) through the centre of the perforated waste and extraneous gas flue, showing also the back chequered by-pass flue. Fig. 2 is a vertical section across (CC), Fig. 1 showing the longitudinal structure of the by-pass arrangements, and Fig. 3 is a plan of (DD) Fig. 1. The general method of working is not easy to explain in a description of any reasonable length, but, as already stated, consists of external heating in which, in addition, up to 25% of the heating gases passes through the charge through perforations in the retort. The external heating takes place on the outside only of the twin retorts, whilst a central vertical discharge or offtake passage is arranged between, connected to the exhauster main, and into which is discharged the gases and volatile products from the two retorts. This arrangement is said to reduce cracking of the light oils to a minimum. The combustion chambers are arranged in three or four zones, and for average low temperature carbonisation the top charge zone may be at, say, 750 deg. F. (400 deg. C.), giving hydrocarbon and oil formation, the next at 1,110 deg. F. (600 deg. C.) for the evolution of oil, the third stage at 1,380 deg. F. (750 deg. C.) for ammonia and gas evolution, and the bottom and final stage for gas evolution and coking of the residue at 1,470 deg. F. (800 deg. C.), depending, of course, on the circumstances, but always on the principle of a gradually increasing temperature. The amount of gas evolved per ton by the carbonisation of average coal under these conditions about 8,000–10,000 cubic feet at is 450–500 B.Th.U., and of this 4,000–5,000 cubic feet is required to heat the retorts if cheap external producer gas is not used. It is claimed that the final exit temperature to the chimney will not exceed 390 deg. F. (200 deg. C.), and that 75% of the heating walls in the "Everard-Davies" retorts are actually transmitting heat.

The dimensions of the retorts are 9–36 in. in width, 24–36 feet in height and 4 ft. 6 in. to 8 ft. 0 in. in length, with a charge of 10–30 tons, the time of carbonisation, that is for the coal to travel completely through the retort, being 8–12 hours.

Yield of By-Products

As regards the yields which it is estimated will be obtained by the "Everard-Davies" process on straight low temperature carbonisation, the figures in Table I are based on a standard average coal of 12,000 B.Th.U. per lb., with not less than 30% volatile matter, or over 8% water and 10% ash. The existing (high temperature carbonisation) gas process with such average coal will give the following yields per ton of coal, taking the figures for the ordinary horizontal gas retort and the modern vertical retort.

TABLE I.

	Horizontal Retort	Vertical Retort
(1) Coal gas (stripped)	12,000 cu. ft. (500 B.Th.U.)	14,000 cu. ft. (450 B.Th.U.)
(2) Coal tar	10 gallons	12 gallons
(3) Benzole and toluol from stripping the gas ...	3 gallons	3 gallons
(4) Sulphate of ammonia	25 lbs.	45 lbs.
(5) Saleable coke	12½ cwts.	12 cwts.

The "Everard-Davies" process with similar coal is claimed to give, with eight hours' carbonisation at 1,380 deg. F. (750 deg. C.). See Table II.

TABLE II.

(1) Coal gas	8,000 cu. ft. (500 B.Th.U.)
(2) Coal tar	15 gallons (including 10 gallons "Diesel" oil).
(3) Benzol	2 gallons.
(4) Sulphate of ammonia	30 lb.
(5) Saleable low temperature fuel (10–15% volatile matter)	14 cwt.

In addition to the ordinary "straight" low temperature carbonisation process, the following additional auxiliary methods of working can be adopted :—

(1) Steaming the retorts on the zone system, the steam being first

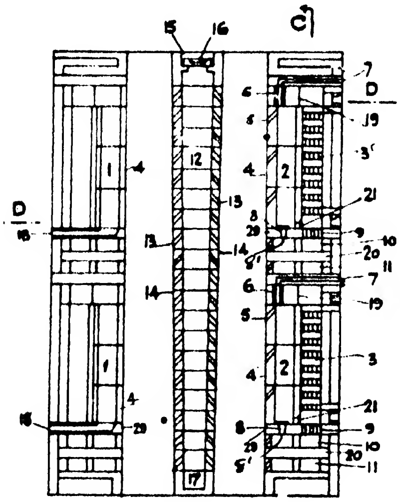


FIG. 1.

SECTION A.A. SECTION B.B.

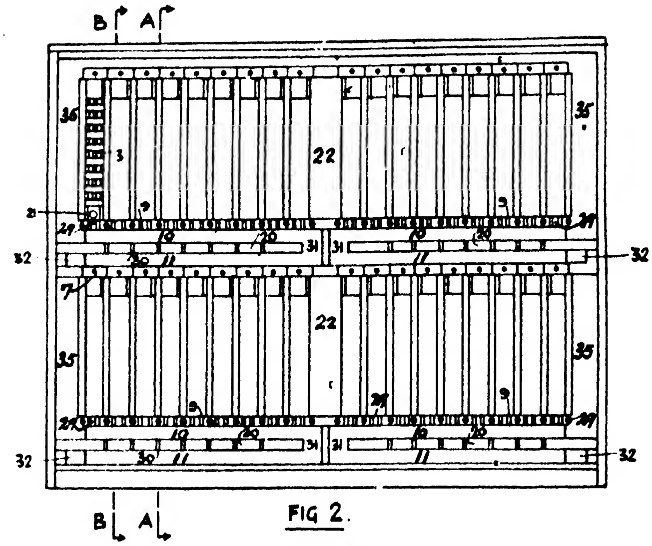


FIG 2.

SECTION C.C.

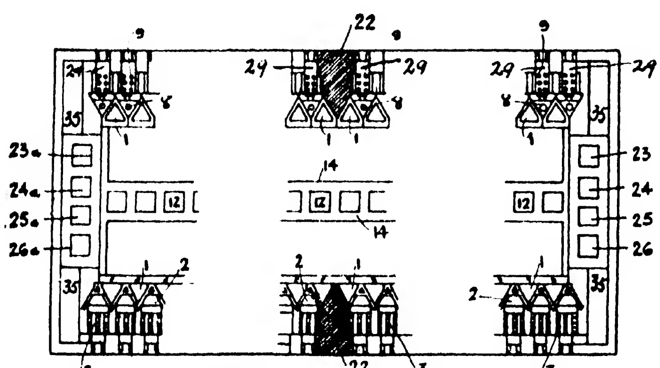


FIG. 3. PLAN D.D.

superheated and then introduced into each of the three or four zones of perforated flues, and not merely as in ordinary vertical retort work admitted as a single steam jet at the bottom of the retort. A convenient amount is 5–10% steaming, which increases the gas and ammonia yields.

(2) It is also claimed that the yields may be improved by the addition of various gases, such as hydrogen, from outside sources along with the steam.

(3) Also a further variation is to construct the retort of a conductive material like carborundum, with the object of passing an electric discharge through the internal heating gases as they enter the charge, to increase the ammonia yield.

The Use and Advantage of Electric Power in the Factory

(*Continued from page* 389)

Where warps are manufactured for sale, a new method of warping is finding application, particularly in Dundee, viz., link or chain warping. The *Linking Machine*, so called, which was introduced from the cotton trade, consists of the usual bank or creel, a leasing apparatus, a measuring machine, and the linking machine proper. The linking and the measuring machine alone are power driven. They are mechanically coupled together, and driven as one machine absorbing about 1·5 b.h.p. In some machines two warps may be linked at once, or one only may be dealt with.

Instead of converting the warp into a chain by the process just described, it may be passed into a machine called a *Ball Warping Machine*, which delivers the warp wound on a series of rollers not unlike "cheeses," but larger. This machine takes approximately ·5 b.h.p. to drive. Whether prepared in the linking or in the ball warping machine, the warp has to be put through a beaming machine, in some cases after being dressed, and in other cases in a "green" condition.

(*To be continued.*)

Fireproof Doors*

Some interesting tests on modern fireproof doors

IT is a recognised fact that although it is impossible entirely to prevent outbreaks of fire, a great conflagration, with its consequent extensive damage, can be avoided by confining the fire to the small area in which the outbreak originates. This can be accomplished only by dividing buildings into fireproof compartments, and by protecting all communicating openings with doors that are really fireproof and not so merely in name. There are many types of doors which are called "fireproof," and with some persons the idea prevails that fireproof doors are constructed of wood covered with tin.

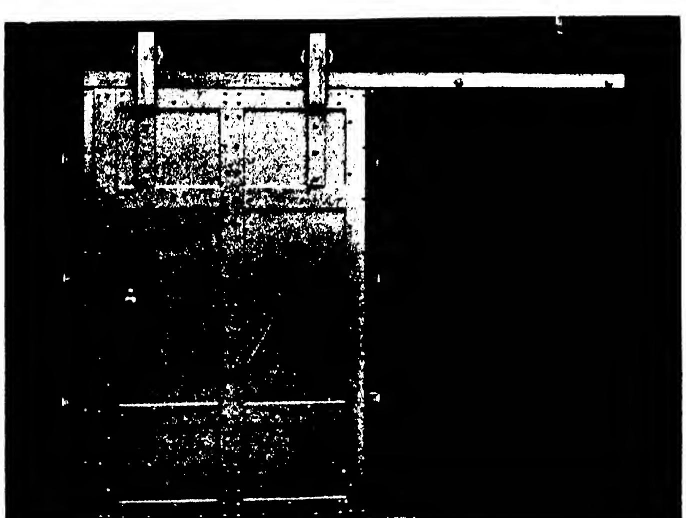
Until the year 1910, these tin-covered doors were considered very satisfactory by authorities on fireproof construction. In theory, perhaps, they were all right, but in practice they were far from perfect, and suffered from the following defects :—

(1) Dry rot ;
(2) No resistance to wear and tear, especially where there is rough and heavy traffic through the openings ;
(3) Warping ;
(4) The tin sheathing perishing in damp atmospheres ;
(5) Bursting and collapsing under the combined effects of fire and water.

Steel doors, on the other hand, were supposed to be very substantial, but liable to buckle when subjected to the intense heat of a fire.

Realising that the many defects of tin-covered doors would be avoided if replaced by solid steel doors the firm of constructional engineers, whose products are here illustrated, spent years in perfecting the design and construction of the latter, and in 1910, two of their doors were purchased privately by the Fire Offices' Committee for the purpose of making independent tests, although the makers were unaware of this at the time.

In November, 1910, the Fire Offices' Committee officially tested various types of fireproof doors, each being subjected to a temperature of 2,000 deg. F. for a period of two hours, followed by a five minutes' drenching by water at a pressure of 90 lb. These tests resulted in the complete triumph of steel doors, which not only withstood the test, but were so little affected by the heat and water that they were resold, and have been in constant use ever since.



Steel Sliding Door — *John Booth & Sons*

Subsequently the Fire Offices' Committee completely revised the rules for fireproof door construction, and in July, 1912, issued a new edition, which has remained as a standard ever since. In this edition the place of honour is given to steel doors, the allowable area of the openings having been increased from 35 to 56 square feet. Not only so, but steel *sliding* doors, which previously had been forbidden, were allowed to be used freely, and the regulations governing steel sliding doors were modelled on the standard practice followed by the makers whose doors we are describing. In fact, the tests changed the situation completely, and the firm has made steel fireproof doors up to 400 square feet. Another point in favour of steel fireproof doors is in connection with salvage, for, while tin-covered doors are useless after a fire, steel doors can be touched up and refixed after a conflagration, and even after disastrous explosions.

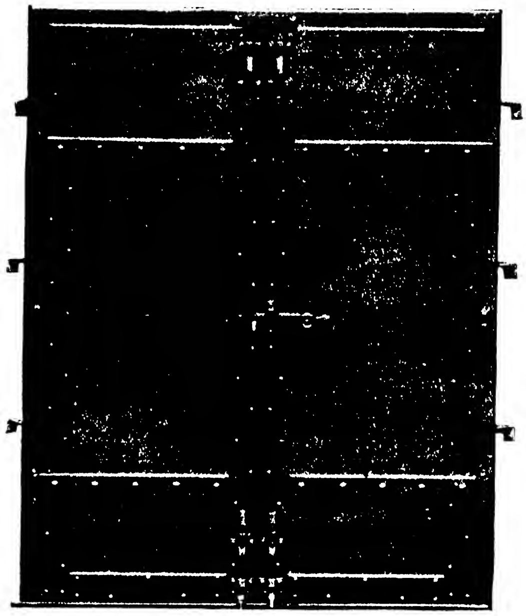
Buildings and warehouses fitted judiciously with steel fireproof doors not only limit the ravages of fire, but save their proprietors a considerable sum annually in insurance premiums.

With regard to hinged steel doors, some manufacturers use either butt or pivot hinges, but Messrs. Booth prefer hinged-bands, which are carried right across the leaf of the door and form part of the panelling, so that a thorough grip of the whole door is obtained. To prevent warping when the door is subjected to the heat of a fire, it is held at the top and bottom by shoot bolts, and at the side by the hinges, while between the hinges is a small adjustable lug under which the edge of the door fits when closed. Hinged doors can be built to turn outwards or inwards with equal facility, and they can be fitted with espagniollette bolts if desired. In the Booth design of sliding steel door, the weight is carried

* *Steel Structures*, April, 1922.

by large pulleys mounted upon hardened steel ball bearings and running on a specially shaped rail. With this construction, the heaviest doors, weighing 15 to 25 cwt. each, can be moved along the rail quite easily by one hand without any appreciable effort. When closed, the sliding door is held all round in a groove, so that if there is any tendency to buckle or warp, the door cannot work loose from its frame, but is held firmly on all four edges. This grooved construction follows somewhat the principle adapted in the manufacture of flame-proof mining switch gear, in which grooves and tongues protect the joints, no flame, whether it be generated inside or outside, being able to pass around right-angled corners formed of metal.

It is of interest to note that the demand for steel fireproof doors has increased so greatly that Messrs. John Booth & Sons, of Bolton, who manufactured the steel doors which withstood so remarkably the "ordeal by fire" referred to previously, and are the makers of the doors of which we give illustrations, have been compelled to form a special department for their manufacture, and have standardised both hinged and sliding doors. They now keep in stock doors of all sizes in general use, so that immediate delivery can be given.



Hinged Folding Steel Doors — *John Booth & Sons*

In this connection, the makers ask ask us to draw the special attention of architects and engineers to the desirability of adopting steel fireproof doors of standard size rather than to specify doors of odd dimensions. Not only will delay in delivery thus be avoided, but it is probable that an appreciable saving in the cost will be effected. Where no standard size of door conveniently can be allowed for, Messrs. Booth are able, of course, to work to any dimensions specified.

The Provision of a Pure Water Supply by means of Evaporators

In some cases the only water available for boiler plant and general industrial purposes is of such bad quality that it is a paying proposition to instal evaporators to distil pure water, such as is the common practice in marine work. This is particularly the case when water, which may not be beyond treatment in ordinary softening plant so far as the removal of scale-forming elements is concerned, contains, in addition, large amounts of salts, such as common salt, which either cause corrosion, or excessive frothing and priming, especially in water-tube boilers. The presence of sodium sulphate, for example, is particularly objectionable from this latter point of view.

A "single stage" evaporator is simply a closed tubular heater, in which the live steam passes inside the tubes, and the impure water is on the outside, this arrangement being devised for ease in cleaning. The steam evolved is then condensed to pure water in a cooling coil, whilst the condensed water from the inside of the steam coil is of course also collected. Theoretically, of course, 1 lb. of live steam should produce 1 lb. of distilled water, but in practice the figure is about 0.8 lb., corresponding, therefore, to 80 per cent. efficiency. For a large plant a much more economical arrangement is a "multiple-stage" evaporator, in which the steam given off from the first stage in condensing is used to heat the cold water in the second stage, and so on for a number of stages, the amount of live steam required for evaporation in each stage being of course much reduced. Thus, for example, if it takes theoretically 1 lb. of steam to produce 1 lb. of distilled water in a 1-stage evaporator, then 2 lb. of distilled water in a 2-stage evaporator would require about $1\frac{1}{2}$ lb. of water, and 3 lb. in a 3-stage evaporator about 2 lb. In practice a 2-stage or 3-stage evaporator is generally used, since above this the cost of the installation and the complications swallow up the extra saving. Such evaporators can be worked with either live (high pressure) or exhaust (low pressure) steam, the latter being worked in conjunction with a vacuum, and it is often a very economical proposition to collect all the exhaust steam available and use it for this purpose. Another arrangement is a mixed pressure evaporator, in which the exhaust steam is normally used, and when this fails live steam is automatically injected. Also the live steam or high pressure evaporators are in two types, in the sense that they are arranged to discharge condensed water, either cold or practically boiling, according to circumstances.

A Visit to Messrs. Henry Berrys' Works

Recent developments in heavy hydraulic machinery

THE firm of Henry Berry & Co. Ltd., of Leeds, England, has been for upwards of forty years "specialists" in the production of hydraulic machinery and special machine tools required for the Indian market, foremost amongst which is the manufacture of hydraulic baling plant. The subject of baling plant for cotton, jute, wool, silk, esparto, and other fibres has, since 1890, formed a very interesting part of this firm's manufactures, and they have on their staff, and in their employ, experts in this class of work. The experience gained has been principally based on the actual and successful results obtained in the packing of the several materials, to a great extent in their own presses.

These presses have been supplied to some of the foremost firms in India, and have resulted in many cases of repeat orders time after time, and the firm always carry a considerable stock of presses of various descriptions, so that in all cases quick delivery is ensured.

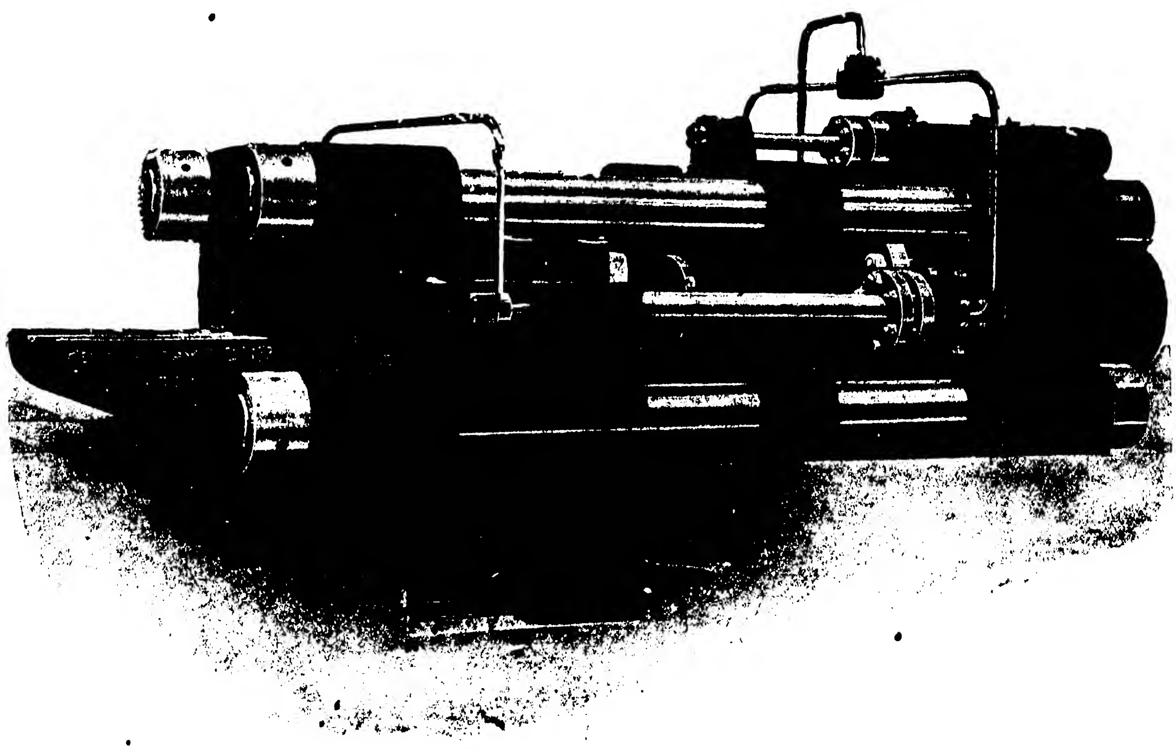
The presses for cotton and jute generally are the ordinary half press and finisher (this necessitates the use of extractor to convey the half press bale to the finisher). The "Cummins" vertical press is self-contained, with two or three cotton boxes from which the cotton is pressed into a revolving chamber, the bale being finished over the finishing cylinder after the total amount of cotton has been collected from the boxes. (This necessitates the use of a locking ring.)

Messrs. Henry Berry have had a very great success with their "Leeds" press, which is somewhat similar in action to the "Cummins" press, and is of the vertical type. It has two or three chambers, as required, for the cotton, together with revolving box, but in this press the locking ring, balance weights, levers, etc., are dispensed with, and, as a result, a greater out turn is obtained at a much less cost per bale. This press can be made either for end pressing or flat pressing, as required. In the latter case this would become a ground floor press, all the boxes being short.

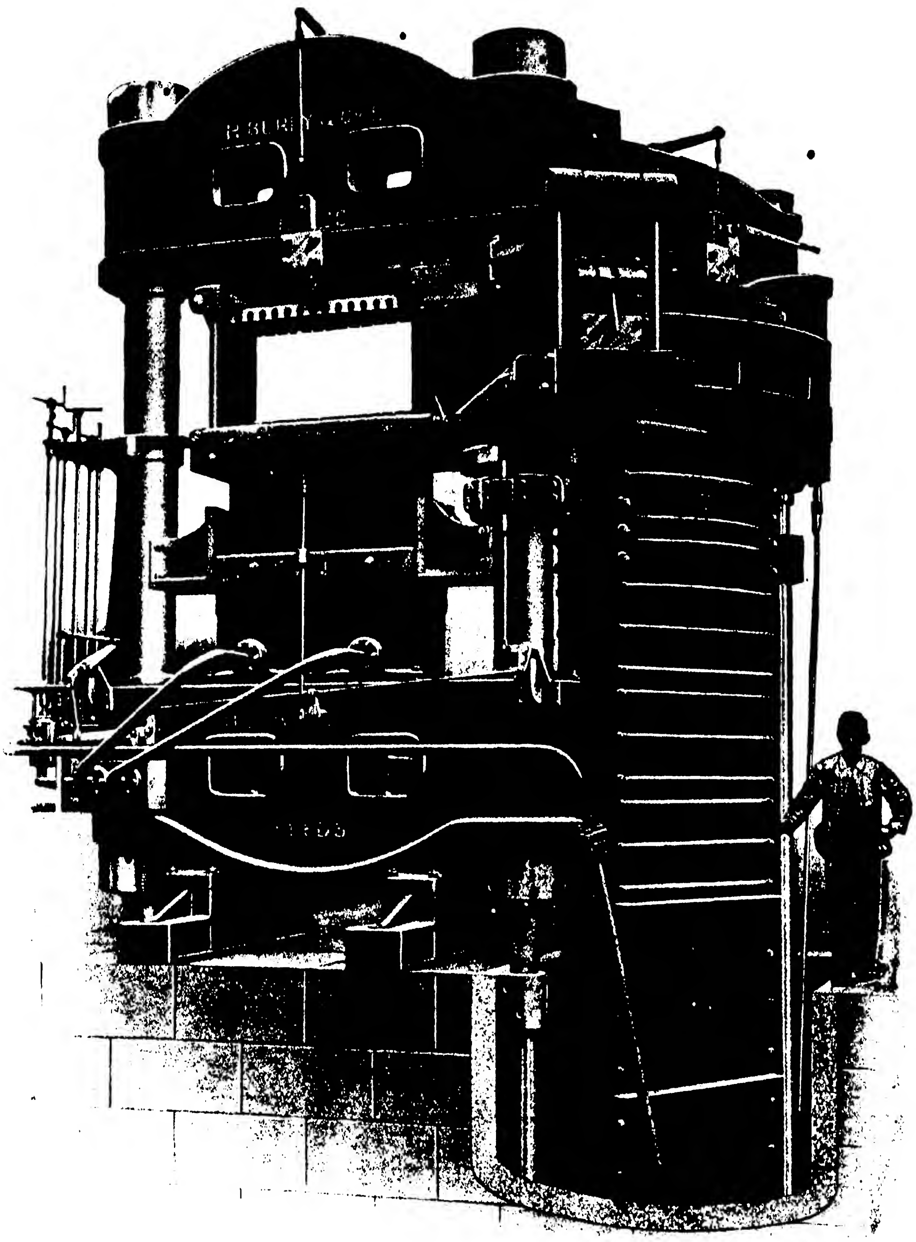
They also make a type of press known as the "Watson" press. This is a press having a half press and finisher combined with a treble revolving chamber at the top, and is particularly applicable for the pressing of jute. Very large outturns have been obtained from this machine, 55 bales per hour being a very ordinary result.

They also make the "Grid" press. The pressure on the bale of this type is applied from the top, after the cotton or jute has been half pressed from the bottom.

A very simple type of press for up-country work is the "Moffusil" press. This is used for either end pressing or flat pressing, and only necessitates



Horizontal Press



Vertical Press

ground floor building, the foundations also being very small, and this machine could be so made as to take the place of a half press and finisher, with a result that the out-turn would be increased to almost double, and would take up much less room, the foundations required being comparatively about one-fourth.

For wool, copra, roots, hides, etc., special presses are made, and a speciality is made of hide pressing, whether for dry or green hides.

The subject of pumping for these classes of work is one to which very great attention has been given, with the result that great economy has been effected, and very successful results have been obtained, both as to first cost and applicability to their respective requirements. The steam driven pumps are self-contained, and are made in several sizes and types, and are thoroughly up to date. The horizontal pumps are so arranged that they can be driven electrically, or could be connected to gas, steam, or oil engines, as may be required. Great care has been given to the design of these pumps, so that best results may be obtained with the least possible working expense.

Plant for the production of steel railway wagons. The production of steel railway wagons in India is one of the latest developments in Indian business, and Messrs. Berry have just recently supplied a complete installation of special hydraulic presses and

other machinery for this purpose to the well-known firm—The Indian Standard Wagon Co., of Howrah.

Plant for the production of steel railway sleepers is a speciality of theirs to which they have given special attention, and they have supplied several plants to British manufacturers, and lately a complete installation for the mass production of steel sleepers to The Tata Iron & Steel Co. Ltd.

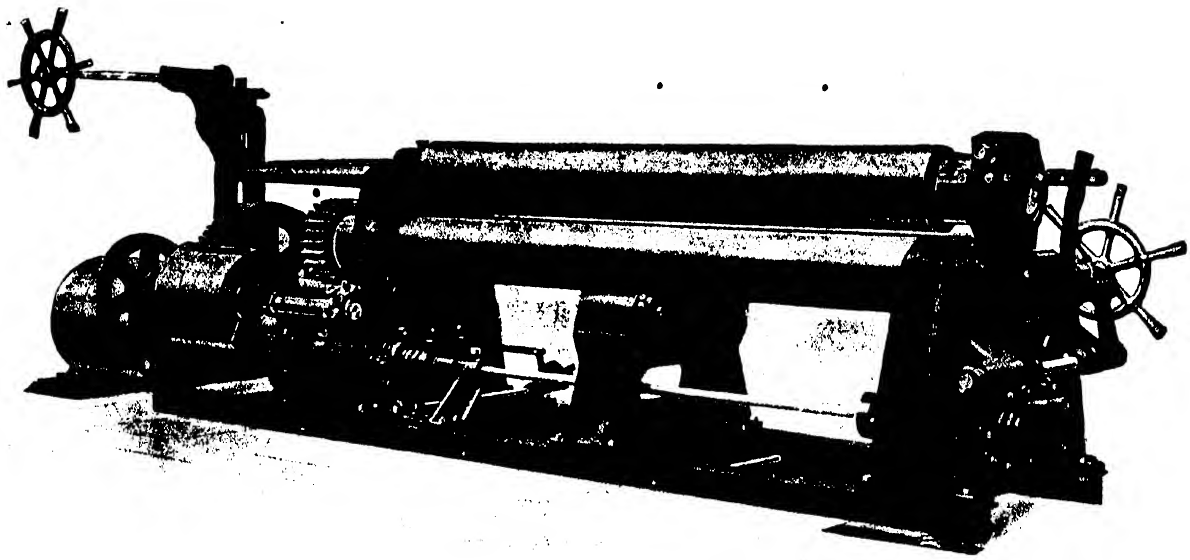
Plant for railway workshops is another phase of their manufactures, the production of which has been carried on since the firm was established, and they have supplied machines for railway workshops to all the leading railway companies in India.

Hydraulic plant for the manufacture of pipe lines. In this class of work they are pre eminent, and they are at present engaged in the manufacture of the plant for the execution of the contracts for the Bombay pipe line and also for the Calcutta pipe line.

Sand excavators. Special attention has been paid to the manufacture of sand excavators for sand stowing in mines, and they have recently completed a contract for these machines for India.

The foregoing are the firm's chief specialities, but they have had considerable experience in the building of heavy shipyard tools, metal extruding plants, steelworks plant, steam and electrically driven excavators, and combined excavators and conveyors.

The works are equipped with the most up-to-date machinery for the rapid execution of orders, and owing to their long and varied experience, they are in a position to carry out the manufacture of all classes of hydraulic and other machinery for the Indian market.



Heavy Plate Rolls

"O.R." Traffic on Indian Railways

For a long time past there has been considerable dissatisfaction throughout India with the conditions under which railway traffic is conveyed at Owner's Risk. This, it may be added, is shared by the trading community in other countries, the question being probably one of the most contentious in connection with traffic conveyance. The general question has recently been considered in India before a Railway Risk Note Revision Committee, before which representatives of the traders, and the railway companies have given evidence. There is, naturally, a sharp conflict of opinion as to the liabilities covered by the risk note, and the traders are anxious that the railway companies should undertake further liabilities on the basis of present rates. On the other hand, the companies contend that any additional liability undertaken would have to be "insured against" by the imposition of higher rates. Both points of view are sound. If a trader takes advantage of a lower rate for the conveyance of his traffic, he must be prepared to accept the conditions but they should be reasonable. The railway companies, it is understood, are prepared to modify the conditions in some important respects, and when a settlement has been effected, we shall return to the subject.

The Magnesite Industry in India

(*Continued from page 306.*)

By EDGAR C. EVANS, B.Sc., F.I.C., M.I.M.E.

All the illustrations are by courtesy of Messrs. Sutcliffe, Speakman & Co. Ltd.

It is well-known physical law that the purer a substance is, the higher the melting point. The addition of an impurity invariably reduces the melting point. Such is the case with magnesite. Some natural magnesites contain such a proportion of impurities that their sintering point is lower by some hundreds of degrees Centigrade than those of other magnesites. An idea of this can be gained from the following representative magnesites from various parts of the world.

ANALYSIS OF RAW MAGNESITE.

Source.	Specific gravity.	Silica SiO_2	Iron oxide and Alumina	Calcium Carbonate.	Magnesium Carbonate.
Greece	2.8	0.90	0.86	2.74	95.50
India	3.58	1.34	0.14	2.18	96.30
Asia Minor ...	3.00	0.43	0.86	2.49	96.22
Cyprus	2.75	0.52	0.11	11.62	87.75
Styria	3.00	0.80	4.30	0.10	94.80
Canada	2.90	2.00	1.00	9.00	88.00
California	3.00	2.75	0.80	2.78	93.66

Two very significant features arise out of the above table, viz. :—

(1) The Indian magnesite has a higher degree of porosity than any one of the natural magnesites.

(2) The proportion of iron oxide and alumina in Styrian magnesite is higher than that in any of those quoted.

Styrian magnesite bricks are practically a standard in the industry. They have always given consistently better results in practice than bricks from any other source. English magnesite bricks have not yet in fact attained the pre-eminence in the iron and steel industry possessed in the past by Styrian bricks, and this despite the fact that Grecian magnesite from which British bricks are made, is a considerably purer product than the Styrian magnesite.

As a matter of fact, the superiority of Austrian magnesite is due primarily to the fact that the raw material contains such a proportion of impurities as to make it far more easy to work up than Grecian magnesite. It has a far longer range of vitrification than Grecian magnesite, and for this reason can be burnt at a lower temperature. Up to a certain point, then, the presence of impurities in a natural magnesite is advantageous rather than otherwise, and this opens up some very interesting possibilities in the case of Indian magnesite. In its natural state it is too pure, and the first essential in obtaining a high-class product is to reduce its purity to a point which will allow it to be more easily worked. This must, of course, not be done indiscriminately. The correct type of impurity must be added in the correct proportion, and the process of mixing must be performed in the right way. It is a question that must not be done in any haphazard manner; conditions must first be determined in the laboratory, and only when a complete scheme has been worked out can the laboratory results be translated to the commercial stage.

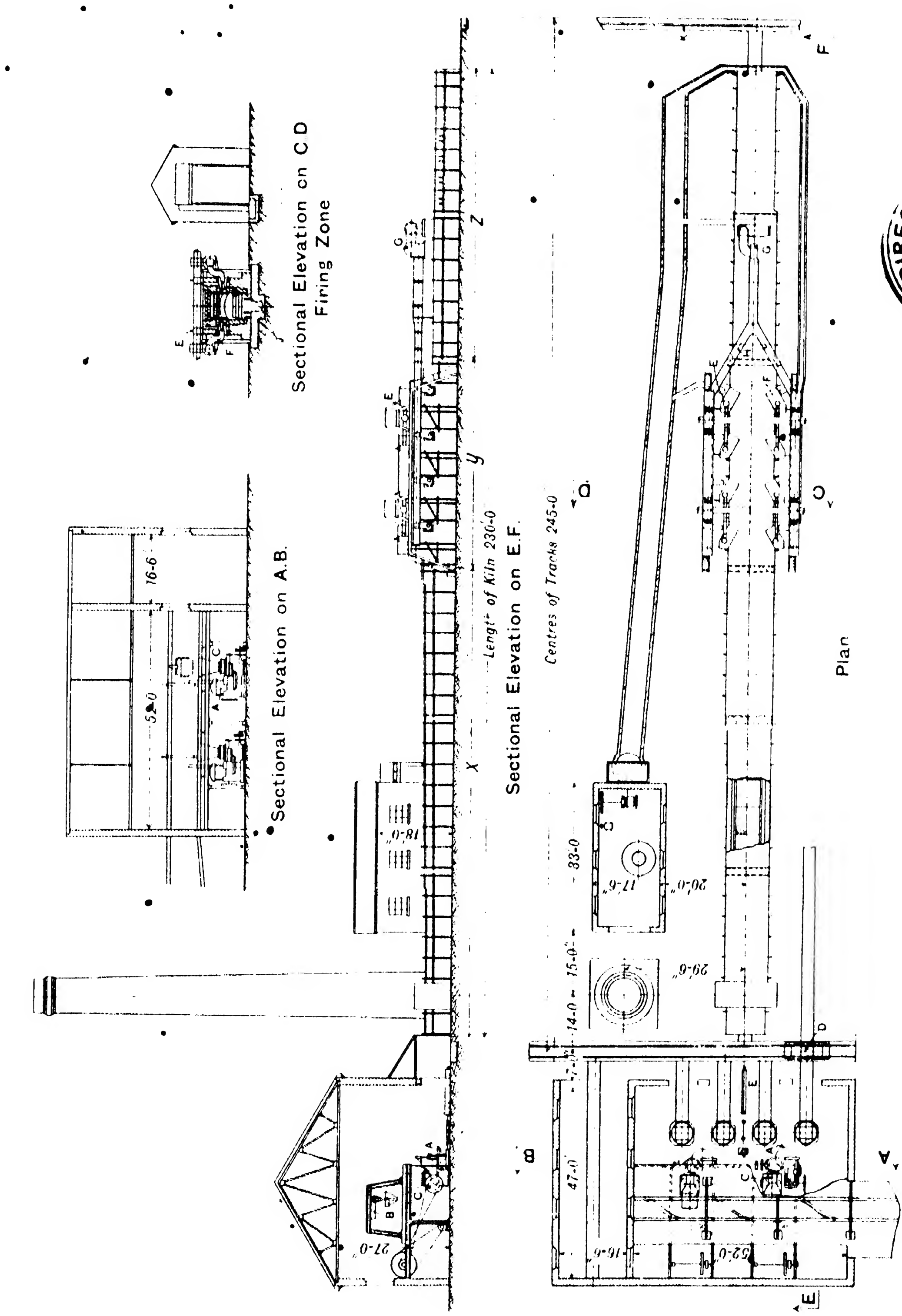
Research work on Indian magnesite has, however, already been carried out, and results show that it is a comparatively easy matter to so treat the product as to produce a high-class brick at a comparatively low temperature. This result removes the last of the technical difficulties associated with the establishment of a magnesite industry in India on a very large scale. To meet conditions in India, however, it would be advisable to start on a comparatively modest scale, and as experience was gained, and a demand created for the bricks, to gradually build up the industry.

It would be better, therefore, at the outset to start with a comparatively modest installation of, say, 500,000 bricks per annum, a size of plant which would allow of a good return on the capital expenditure involved.

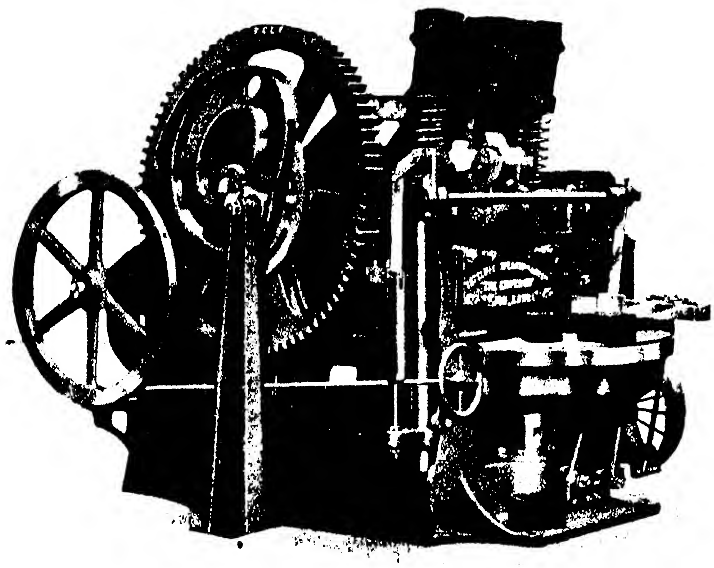
Process of Manufacture

With a plant of this size there would be no necessity to erect two kilns, viz., one for the raw magnesite and the other for burning the magnesite bricks. One kiln only need be erected, which could be used either alternatively for the two operations, or, if required, both operations would proceed at the same time. The first step, however, would be the preparation of the raw material, that is, the toning down of the magnesite on the lines suggested above. This is not a simple mixing operation. If standard and consistent results are to be obtained, an absolutely uniform product must be prepared for sintering, and this can only be done by a complete mixing and grinding plant, which would automatically collect the raw materials involved, and deliver them automatically in the correct proportions, and in the physical condition desirable to ensure a product which would be easily worked, and which would give a high-class manufactured article.

This operation is of vital importance, and no attempt should be made to cut down capital costs with this portion of the plant. It would only be false economy, and would react seriously on all the subsequent stages of manufacture. This portion of the plant should be absolutely automatic, and once conditions are standardised, once set to produce a product of the right chemical composition, possessing the necessary



Proposed Lay-out for Magnesite Brick Making Plant



Brick Press

physical characteristics, it should be able to work with the attention of practically unskilled labour.

There are, however, no technical difficulties in designing such a plant. Intimate mixing and preliminary preparation of raw materials are a feature of a number of industries, as, for example, the cement industry, or the preparation of high class sand lime bricks, so that no new engineering difficulties are involved. It is all a question of suitable plant.

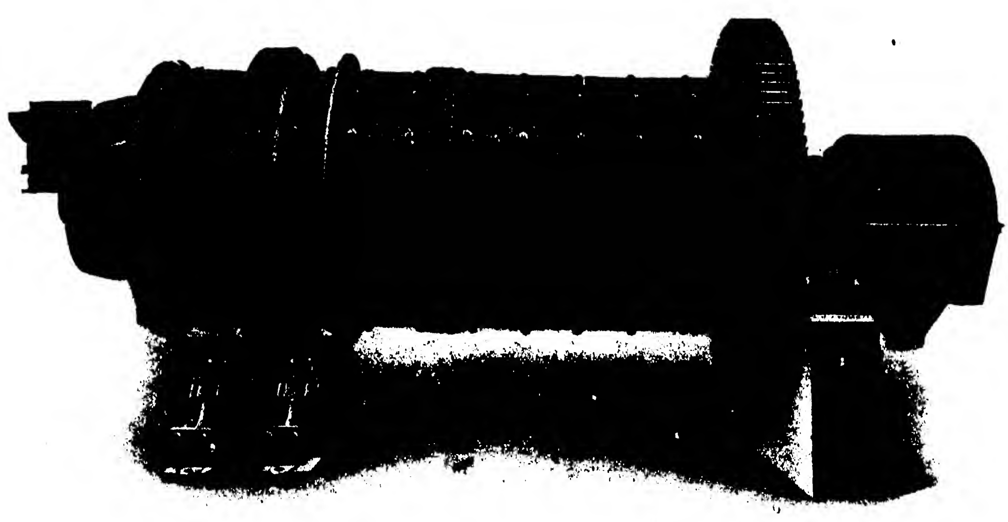
The next stage is the burning of the raw prepared material. In some cases it is found desirable to briquette the raw material prior to treatment in the kiln. This would probably be the most suitable method of treating the material obtained in accordance with the above procedure. The briquettes of dead burned magnesite could be broken up after burning, for subsequently making up into the magnesite bricks.

The type of kiln to be adopted, both for burning the magnesite and for the production of bricks, is a matter for serious consideration. The general practice in England is to use a chamber kiln for magnesite brick manufacture. In some cases a regenerative bottom is used, whilst in others this is omitted. Generally speaking, however, the chamber kilns have not given such satisfaction as the tunnel kilns used for the manufacture of Austrian bricks, and expert opinion is leaning in the direction that the latter give the most satisfactory results in practice. To meet Indian conditions, tunnel kilns would probably be superior to chamber kilns for many reasons, but principally in the following directions:—

(1) Ease of manipulation.
(2) Regularity and uniformity in heating.
(3) Ease with which high temperatures can be maintained.
(4) Low labour charges.
(5) Continuity of operation.

Tunnel kilns have been in operation for a number of years in various industries; they are used, for example, very extensively for burning iron ore briquettes, but a modification is required from the customary iron ore kilns for use with briquettes. Generally speaking, iron ore briquettes are made at temperatures of 1,300 deg. C. to 1,400 deg. C., but a higher temperature would probably be required for magnesite, even after the preliminary treatment above mentioned. For this reason it would be advisable to use a regenerative tunnel

(*Continued on page* 411.)



Sieveless Ball Mill for Grinding Magnesite

HOW & WHY THINGS WORK

Conducted by J. HAGGIE-PATTERSON, Assoc. M.I.C.E.

THIS SECTION IS PRIMARILY INTENDED FOR ENGINEERING STUDENTS AND DEALS IN SIMPLE LANGUAGE WITH THE CONSTRUCTION AND WORKING OF VARIOUS TYPES OF PRIME MOVERS :: :: :: :: :: AND INDUSTRIAL MACHINES AND DEVICES :: :: :: :: ::

The Locomotive (vi)

The following short article concludes the series on the locomotive, and deals with brake power and horse power

CONCLUDING this brief series of talks on the locomotive, we propose to refer to the brake power used, and to touch upon the various types. The type generally used on the India railways is the vacuum brake, but in England both the vacuum and the Westinghouse are used, and the steam brake is generally used on goods and shunting engines.

The principle of the vacuum brake is that the air is withdrawn from a cylinder fixed to the locomotive, thus creating a vacuum as perfect as possible, which represents a pressure of 14.7 lb. per square inch. The creating of this vacuum keeps the brakes from acting, but should once this vacuum be destroyed, either wholly or partially, then the brake blocks are forced on to the wheels, through the medium of the pull rods, which are in direct communication with the piston which works in the vacuum brake cylinder. Taking into consideration that the vacuum brake cylinder diameter is about 24 in., it follows that the total possible pull or force which can be distributed upon the brake blocks is about 3 tons. When the locomotive is attached to a train, there is a continuous pipe coupled up which runs throughout the train. This pipe is in communication with the brake cylinder on each vehicle, and thus, when the driver partially or wholly reduces his vacuum, the action applies to the brake on the locomotive, and on each vehicle, according to the amount of vacuum reduction.

The Westinghouse brake operates with compressed air, the pressure being obtained by means of a steam pump. A supply of compressed air is retained in a steel cylinder, and is applied to the brake cylinder piston whenever the driver reduces his air pressure to the extent of, say, 10 or 12 lb. This reduction automatically causes a small valve to move, which allows the compressed air to flow into the brake cylinder. This system of braking is also continuous throughout the train to which the locomotive is attached, but owing to the totally different type of fitting required for the vacuum and Westinghouse brakes, some rolling stock is equipped with a dual set of fittings, that means to say that it has both the vacuum cylinder fitted to it, and its necessary attachments, and also the Westinghouse and its necessary fittings, so that the train can be drawn by an engine which carries either the vacuum or Westinghouse brake. Comparing the two types, the vacuum brake is much the simpler, the vacuum being created by blowing steam through cones similar to the injector. This fitting, which contains cones, is called an ejector, and is fitted to the back end of the boiler. In the case of goods and shunting engines using the steam brake, steam is merely taken from the boiler and put into the brake cylinder, and thereupon acting on the piston, thus drawing up the brake blocks on to the wheels. Great care must be taken when applying brake power to a locomotive, because, if applied too rapidly, the blocks grip the wheels, and the locomotive, together, possibly, with part of the train, will merely begin to slide along the rails, which may mean a very serious matter

In conclusion, a few words might be said about the horse power of the locomotive, and, taking an average Indian type, say 5 ft. 6 in. gauge, 4-6-0 type, cylinders 20 in. diameter, 26 in. stroke, boiler pressure 180 lb. per square inch, driving wheel diam. 6 ft., and if such locomotive was travelling at 60 miles an hour, the indicated horse power developed would be about 1,248, and would be using only 60 per cent. of the steam pressure, due to the loss of pressure which occurs during the passage of the steam from the boilers to the cylinders, and also owing to the cutting off of the steam by the slide valve, which allows expansion to take place. The above figure is obtained from the formula :

$$\frac{PLAN}{33000}$$

Where P = Pressure per sq. in.
L = Length of piston stroke in feet.
A = Area of piston in inches.
N = No. of revolutions per minute.

$$\frac{\left(\frac{6}{10}\times\frac{180}{1}\right)\times 2\frac{1}{6}\times\left(\frac{22}{7}\times\frac{100}{1}\right)\times\frac{280}{1}}{33000} = 624$$

This figure must be doubled, because of the two cylinders.

Giving a total indicated horse power of 1,248.

Before closing we might refer to the fact that roller bearings are now being tried in connection with locomotive axle boxes, and we should imagine that if this idea is tackled in the right way, that it should be very successful in increasing locomotive efficiency.

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE :: :: :: :: DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS :: :: :: ::

The Use and Advantages of Electric Power in the Factory

By J. F. CROWLEY, D.Sc., B.A., M.I.E.E.

(*Continued from page 345.*) *All illustrations are by courtesy of The English Electric Co. Ltd.*

THE JUTE INDUSTRY

CLOSE on 90 per cent. of the world's jute is grown in the Presidency of Bengal, the principal supply coming from the northern and eastern belts. Behar and Orissa come next as a source of supply, followed by Assam, a small contribution being made by the State of Cooch Behar.

The output of raw fibre for the past 20 years has varied from 6½ million bales to 10½ million bales per annum, the latter record figure being reached in 1914. This is sold at a price which fluctuates considerably, varying during the war, for instance, from Rs. 35 to Rs. 75 per bale. For statistical purposes it may be taken at an average of Rs. 50 per bale.

Somewhat less than one half of the jute crop was exported in a normal pre-war year, the United Kingdom taking about one-third of the exported raw material, Germany about one-sixth, the United States somewhat less, and the bulk of the remainder being divided between France, Australia, Italy and Spain.

It will be clear from the foregoing that the centre of gravity of the world's jute industry does not lie far from the city of Calcutta. The natural tendency to manufacture as closely as possible to the source of the raw material aided largely by circumstances created by the war, such as increased freights, etc., is bringing the centre of gravity closer still. This will be clear when it is realised that the consumption of jute in Indian mills is now more nearly two-thirds of the total crop than one-half as formerly, giving employment in 1918 to 270,000 persons engaged in handling the raw material and in some 80 mills equipped with over 800,000 spindles and some 40,000 looms. This represents a truly remarkable development when one remembers that the first spinning mill was put down in India as recently as 1855 and the first weaving shed in 1859, some 20 years after the manufacture of jute had its first beginnings as a machine industry in Dundee.

Deccan hemp or Bimlipatam jute, as it is sometimes called, is a plant similar to jute, and is grown in Madras and Bombay. About half of the crop of this plant, which before the war did not exceed 400,000 bales per annum, is exported, the remainder being manufactured in three Madras mills almost wholly for Indian consumption.

Jute, Preparatory Processes

Jute is a bast fibre, and as is the case with all vegetable fibres obtained from the stems, as distinct from the leaves of plants, it is found on the outside of the stalk of the plant, and attached to it by a gummy substance. It is usually sown in the months of March, April and May, reaches a height of from 10 to 12 feet, and is cut, not pulled as in the case of the flax plant, before it reaches maturity in the months of July, August and September, and, in some cases, in October. The plant is placed, when cut, in running water or in retting ponds for some 10 to 12 days or longer. When the process of retting is complete, the fibre is easily separated from the woody stalks by hand, or by treatment with a mallet. Power is not employed for the cutting of jute, though it is possible that experiments now being carried out with a view to providing a suitable machine for pulling flax may, if successful, have a bearing on the cutting of the jute plant.

The fibre, after retting and separation from the stem of the plant, is made up loose or in bales, and despatched to Calcutta to the mills or to the press houses for re-baling for export purposes. Loose jute is made up either in drums or in what are known as "kutchha" bales, weighing, if hand pressed, 1½ maunds, and if power pressed, 3½ or 4 maunds each; sometimes for local transport and always for export, it is made up in power pressed "pakka" bales of 10-2/5ths cubic feet capacity, and weighing 400 lb.

Jute, Manufacturing Processes

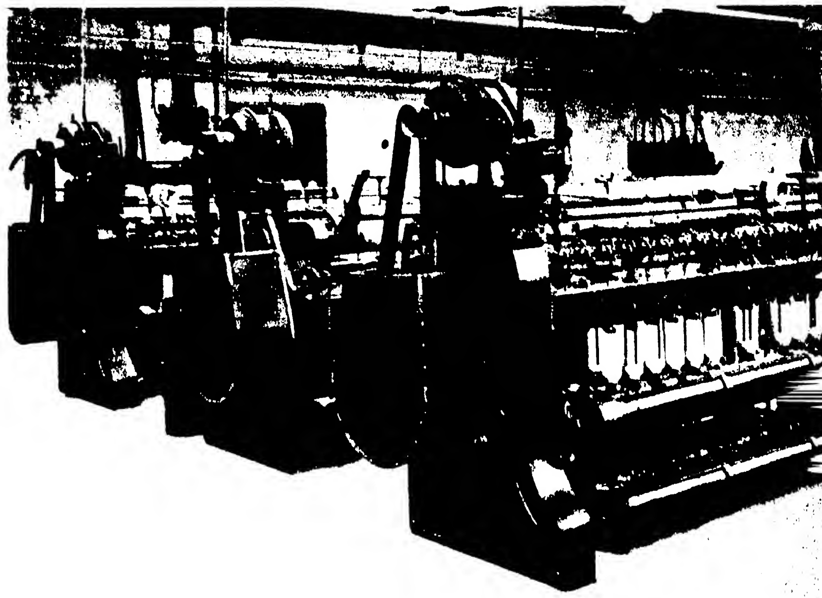
The jute, as received at the factory, is stored in a warehouse, from which it is taken to the jute opener or crusher.

OPENER OR CRUSHER.—This machine breaks up the material of the bales, jute from a number of which is fed on to it at once, and also gives the jute a preliminary softening. The machine is usually run from 115 to 120 r.p.m., and requires some 3 to 4 horse-power to drive. After the jute has passed through the opener, it is made up in "streaks" of a uniform weight by the batchers, who also remove any inferior fibres, and these "streaks" are fed on to a machine called a softener.

SOFTENER.—The softener is provided with a series of rollers, which may be fluted or straight, and during

its passage through this machine, warm water and oil are fed on to the fibre. Where hand batching is employed, the water and oil are added to the jute after its passage through the softener. The object of the process is to soften the fibre and improve its spinning qualities. Softeners vary in size, depending on the number of pairs of rollers, usually from 31 to 79, and the speeds recommended by the different makers vary from 135 to 145 r.p.m.

For estimating purposes, from 3½ to 7 pairs of rollers per B.H.P. may be allowed, softeners with a small number of rollers taking a proportionately larger power than those with a large number of rollers. It should be noted that these machines may occasionally be heavily overloaded for a short period to as much as 60 per cent. in excess of the normal load. A jute softener has by law to be provided with an automatic knock-off motion, which comes into operation if the operative is accidently dragged forward by the feed. After passage through the softeners, the fibre is stacked for over 24 hours, with a view to the more thorough distribution of the oil and water throughout the mass; the fibres are then usually cut by hand and transferred to the preparing department, where the resulting "streaks" are placed on the first machine in that department, viz., the breaker card.



Individual Belt Drive from Motor

Breaker Card. This machine does for the coarser long vegetable fibres like jute and for tow, etc., what is done by a more expensive heckling and spread board or gill box treatment for the finer long vegetable fibres, *i.e.*, it converts them into a long smooth band known as the "sliver." These machines, the cylinders of which are generally 4 feet in diameter with a 6 ft. face, and occasionally 5 ft. in diameter with a 6 ft. face, may run at from 175 to 210 r.p.m., the horse-power varying from 4½ to 6 b.h.p. The starting torque is high, and the load is not always evenly distributed among the machines installed.

In order that uniform yarn may be produced, the feed to the machines has to be controlled at some stage in the process of manufacture. This is usually done by weighing the feed to the breaker card and distributing it over a measured length of feed lattice. It may, however, also be done after the sliver has left the breaker card by passing it into a balling or lap machine.

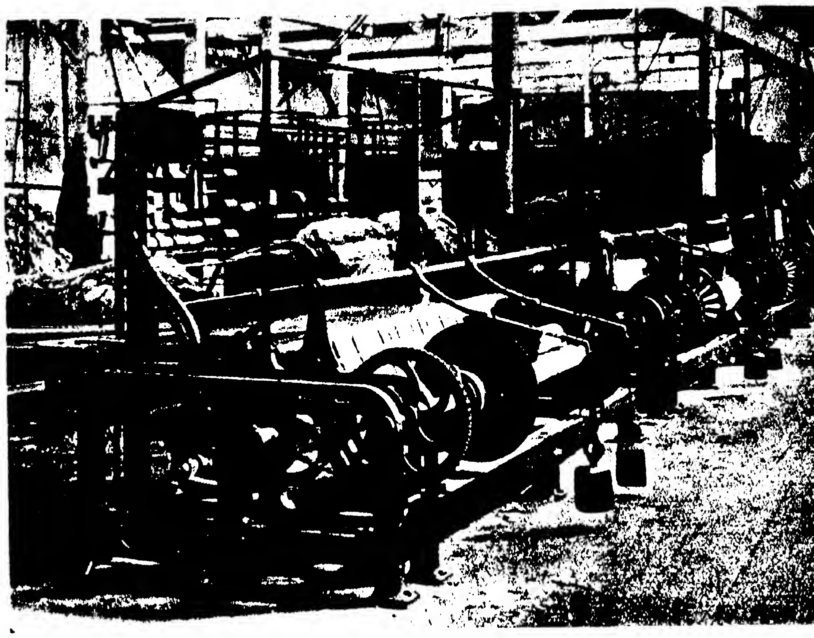
Enclosed Chain Drive

Balling or Lap Machine.- This machine takes a number of slivers from the breaker card and converts them into "laps" of uniform weight for a given length. It is usually run at 300 r.p.m., and takes approximately 1 h.p. to drive. The sliver from the breaker card, or, if a balling machine is employed, the "lap" from this machine is placed on the feed of an intermediate or a finisher card. The designs of the breaker, intermediate and finisher cards are generally similar, and the first and last are as a rule alone employed in Bengal, while, on the other hand, intermediate cards are common in Dundee.

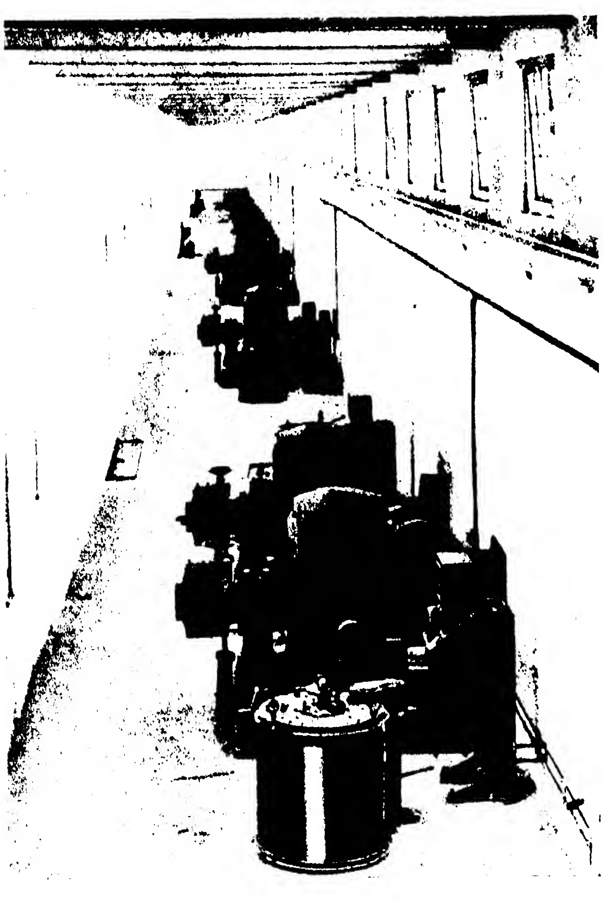
Finisher Card.- The finisher card carries on the work from the breaker card or the intermediate card, as the case may be, cleans the fibres and renders them more parallel. The

speed of the finisher varies from 160 to 220 r.p.m., and the power from 3-4 h.p., being less than that required by the breaker cards. The sliver from the finisher card is also dispatched in a sliver can, and from this can is fed to the first drawing frame.

FIRST DRAWING FRAME. Several slivers from the finisher cards are combined, and pass through the drawing frame together, being elongated, rendered more parallel, and converted into a sliver more regular in weight per unit length. Drawing frames are designed on different principles, the more common being "push bar" and "spiral" drawing, the former largely used for first drawing frames and the latter for second drawing frames. The speeds of these machines vary from 160 to 300 r.p.m., the push bar drawing frames usually running at a higher speed than the spiral frames. The horsepower depends on the number of delivery heads, which are found to vary from 2 to 8, there being usually from 4 to 8 slivers per head. Two heads per horse-power is a safe figure on which to estimate. Spiral drawing requires less power than push bar drawing. From the first drawing the sliver is transferred to second drawing frame.



Special Chain Drive

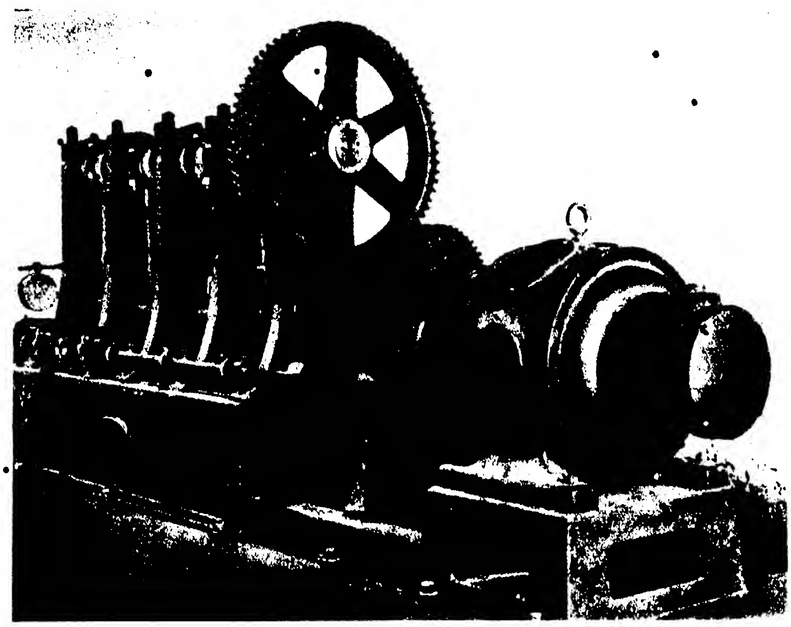


Motors Direct Coupled to Line Shafts

SECOND DRAWING MACHINE. The particulars of this machine are generally as for the first drawing, several slivers being usually run into one as in the case of the first drawing. From the second drawing frame the sliver may be passed on to a third drawing frame of similar design, or, as is more usual in Bengal, to roving frame, which is the last machine in preparing department.

ROVING FRAME. In this machine a slight twist is, for the first time, given to the sliver, in order to permit it to be further drawn out. The roving frame consists of spindles and flyers placed in front of a set of drawing rollers. The speeds of roving frames vary from 200 to 215 r.p.m., the spindle speeds being generally three times this. The number of spindles per frame varies from 40 to 72, and 12 to 16 spindles may be taken per horse-power. From the roving frame the product is passed on bobbins to the spinning frames.

SPINNING FRAME. The dry spinning process is almost invariably employed in jute, wet spinning being reserved for the finer classes of long vegetable fibre such as flax, etc. The frames employed are invariably flyer frames, the flyers of which are positively driven, the bobbins running loose under the control of a drag weight. The traverse of the bobbins varies from 3 to 5 inches, the corresponding spindle speeds varying from 4,000 to 2,000 r.p.m. The spindles are driven by tapes passing round a cylinder and driving on to wharves on the spindles. The machines usually have two sides, the number of spindles per side varying from 64 to 80. The tin drum speeds vary from 400 to 570 r.p.m. There is a variation in the power taken during the traverse of the bobbin, involving a variation between the top and the bottom positions of some $12\frac{1}{2}\%$, the power being greatest when the carriage is at the top. This is due to the unmechanical nature of the drive



Geared Drive to Pump

provided by the tin rollers. This variation is reduced to some $7\frac{1}{2}\%$ by a patent auxiliary tin roller drive that has recently been introduced, which has also had a remarkable effect on the power consumption. The following test figures may be of interest: two frames with the old single cylinder drive gave respectively 12·2 and 11·7 spindles per b.h.p., a frame of the same dimensions and to the same particulars, with the auxiliary cylinder drive and running at a slightly higher speed, but it is worthy of note at a slightly lower tin drum speed (thus showing less slip), gave 16·5 spindles to the horse-power, a remarkable improvement in efficiency. The makers claim rather a higher saving than this, but these figures were actually obtained in independent tests. This drive, either in the patented form or some variation of this, is in fairly general use.

We have now jute yarn, which, depending on the class of fibre selected, and on the adjustment of the preparing and spinning machinery described, is suitable either for "warp," as the threads which run through the length of a woven fabric are collectively termed, or for the "weft," which, "crossing and interlacing" with the warp, makes up a jute or part jute fabric. Whether intended for warp or for weft, if the yarn when it leaves the spinning frame has to be sent to a distance, or sold, it is made up into "hanks" on a reeling or hanking machine. Hanks are made up of a uniform weight, depending on the counts of the yarn, and after leaving the hanking machine are sized and made up into bundles in a hand operated bundling press. The hanking reel is sometimes driven by hand, but is more usually power driven. The *Power Hanking Machine* is usually double-sided and capable of making from 12 to 24 hanks per side. Such a machine, running at 75 r.p.m., and having 20 hanks per side, was found to take ·6 h.p. When the thread is intended for warp yarn, it is generally wound from the spinning bobbins into rolls or "cheeses," the contents of a number of bobbins being absorbed in one roll. This is also done when hank yarns have to be twisted, sized, or otherwise treated. The operation is carried out on a *Roll Winding Machine*. This machine runs at about 240 to 400 r.p.m., and is usually double-sided, with from 20 to 70 spindles per side. A usual power allowance is 24 spindles to the horse-power.

Weft yarn is prepared for the loom in two alternative ways, viz., by being wound as cops generally from $1\frac{1}{2}$ in. to $1\frac{3}{4}$ in. in diameter and 8 in. by 12 in. long, or by being wound on pirns. Cops are placed direct in the loom shuttle, the thread being unwound from the inside, and are now almost universal in jute weaving. A *Cop Winding Machine* is usually double sided with 45 to 60 spindles per side, and runs at from 250 to 440 r.p.m. The spindle speed for 12 in. by 2 in. cops is about 800 r.p.m., and for 10 in. by 1·6 in. cops about 1,000 r.p.m., and the number of spindles to the horse-power varies from 16 for the larger bobbins to 20 for the smaller. A *Pirn Winding Machine* takes about the same power, but runs about 180 r.p.m.

We have now to deal with the warp rolls or cheeses already referred to, and which have to be converted into the long band of threads known as "warp." For use in the loom, also, the warp has to be beamed, viz., wound on to the weaver's beam or beams which are found at the back of every loom.

In most cases, and particularly for the better class fabrics, the warp threads before being wound on the weaver's beam are sized or "dressed," as it is termed. Dressing has many advantages, it improves production in the spinning department as less twist is needed for dressed yarn; it reduces waste, and facilitates weaving. Dressing is now almost universal in the jute industry, the use of the dry, or "green" warps being very limited.

There are many methods employed for preparing warp yarn for the loom. Four distinct methods, each with its own manufacturing variants, are to be found. The author is, however, only concerned with noticing the machines in common use, so that the problem of driving may be more readily considered, and will therefore confine himself to the more general systems of jute warping and beaming.

In all systems a number of warp rolls, or in some cases where roll winding is not employed, bobbins direct from the spinning frames are placed in a creel or bank, generally of V shape, and capable of carrying anything from 40 to 500 spindles, depending on the system adopted. From this bank or creel the yarn, if it is not to be dressed, passes to a *Beaming Machine*. A dry yarn beaming machine may be single or double, viz., it may be fed from one creel or from two creels, one at each end; it may also be with or without drawing rollers. The speed is about 80 r.p.m., and the horse-power from $1\frac{1}{2}$ to 2 b.h.p.

Where jute warps are dressed, the complete operation of dressing, warping and beaming is carried out in a single machine called a *Dressing Machine*. This machine is provided with steam heated cylinders, and has either one set of two cylinders, two sets of two cylinders, one set of three cylinders, or two sets of three cylinders. The machines usually run at about 450 r.p.m., and the more common widths are 60 in. and 72 in., the power varying from 3-$3\frac{1}{2}$ b.h.p.

(*Continued on page 376.*)

Welfare Work in Indian Mills and Factories

SOME very interesting accounts of welfare work in mills and factories in different parts of India were furnished to the first All-India Welfare Conference which was held in Bombay in April last year. These accounts were, however, in most cases brief summaries, and did not do justice to the evident goodwill and the keen desire on the part of the management to better conditions. As the writer of this article has had the good fortune of coming into personal touch with some of those who are in charge of these welfare schemes, this opportunity is being taken of bringing to the notice of the general public the more salient features of the reports submitted to the Conference. It is hoped that this account will also be of interest to other firms, who, while they were not able to send representatives, have also the interests of their employees at heart.

Welfare work, if one may judge from these papers, is primarily associated in the minds of people in India with the well-being of employees *outside* the factory. Thus, for instance, only one firm gives any detailed account of the work that is being done *inside* the factory. It is true that mention is made in most cases of factory dispensaries, but no reference is made to the steps taken to ensure that conditions in the factory do not prejudice the health of the operatives. Again, many firms spend large sums on education and recreation, and presumably they also adopt at the same time measures inside the factory to secure and maintain a stable and contented factory staff, but, with the exception of a paper by a manager of the Tata Mills on "Works Committees and Settlement of Disputes," and one on the same subject by the Superintendent of the Tata Workmen's Institute, little is said in these reports regarding such measures.

In other countries, notably in England and the United States of America, it is this side of welfare work that has been chiefly emphasised, and while what is known as outside welfare work has not been neglected, employers have realised that dissatisfaction with working conditions must first be reduced to a minimum before an attempt is made to ameliorate outside conditions.

Among the reports submitted, that of the British India Corporation, Cawnpore, lays greater emphasis than any other on welfare activities inside the factory. Such topics as methods of employment and discharge, encouragement of better workmanship, labour-saving devices, provision of health comforts, prevention of accidents, rest periods, care of women and juvenile employees, prevention of petty jobberies and tyrannies, works committees and settlement of disputes are all mentioned. Unfortunately details of these schemes are not given. It is of interest to note that they are receiving attention, but it would be still more interesting to know the results achieved.

A common feature of all schemes is the provision of dispensaries within the works. Thus, the Calico and Jubilee Mills, Ahmedabad, the mills and factories of the British India Corporation, Cawnpore, the Buckingham and Carnatic Mills, Madras, the Morarjee Goculdas Mills, Bombay, the Bombay mills belonging to Messrs. Tata Ltd., and the Empress Mills, Nagpur, all provide free medicine and treatment for their employees. In addition, the two last mentioned have engaged the services of women doctors to look after the health of the women and children and to supervise the crêches and the maternity benefit schemes run in connection with their works. The Tata mills have also recently started a system of home visiting in cases of illness, and the mill doctors are informed when patients need to be visited in their own homes.

Besides providing treatment in cases of illness, some firms also give compensation in cases of accident. In the British India Corporation an injured employee is provided with free medical treatment and full pay during absence, and if he is living alone a fellow workman is deputed to attend him. Permanently injured men are given special consideration. Aged widows of old employees are given monthly allowances, while young widows are given a lump sum, varying between Rs. 100 and Rs. 300, which often serves as a wedding dowry. The Calico and Jubilee Mills also give compensation in case of accident, and so do the Empress Mills. At the latter place half wages are given during absence caused by an accident, and employees who have sustained serious injuries are given light work when they return, but draw the same pay as they did at the time of the accident. In the case of fatal accidents the heirs of the deceased receive a minimum of Rs. 300 and a maximum of Rs. 1,000.

In addition to accident compensation the Empress Mills have started a Voluntary Sick Benefit Fund open to all employees. A monthly subscription of Rs. 1-2-0 entitles a man to Rs. 25 for the first six weeks of illness and Rs. 15 for the succeeding eight weeks It is surprising to find that hitherto no one has joined this fund. A similar fund in Bombay for the Tata mills has secured a number of contributors.

Besides giving medical aid at the time of illness, some firms, notably the Empress Mills, Nagpur, the Calico and Jubilee Mills, Ahmedabad, the

Currimbhoy Ebrahim Mills and the David Mills of Messrs. Tata Ltd., provide crèches for young children belonging to their employees. The crèche at the Empress Mills can well boast of the healthy and happy appearance of the babies. It is under the direct supervision of the lady doctor employed by the Mills. The David Mills crèche comes under the care of a lady doctor who is also in charge of the women employees of Messrs. Tata. The healthy atmosphere and the care provided at these crèches are bound to have a very appreciable effect on the health of the children. Careful data are in some cases being collected, but in order to make the comparison complete, data should also be simultaneously collected relating to the health of small children taken into the factory by their mothers.

Closely connected with the above subject is the provision of maternity benefits for women employees. At the Calico and Jubilee Mills women are prohibited from working for a period of three months after child-birth, and are paid Rs. 15 a month during that period. Arrangements are also made for providing a nurse in the mother's own home at the time of child-birth, and subsequent treatment is given free. At the Empress Mills and at the Tata mills at Bombay, women who have worked for eleven months are entitled to a maternity allowance of two months' wages with usual allowances. The women doctors belonging to these mills are largely responsible for the success of these schemes, which, it is true to say, could scarcely be managed without their aid.

Pension Funds

Provident and pension funds are a feature of both the Empress Mills and the British India Corporation, but in the case of the latter only employees earning more than Rs. 50 a month are allowed to join the provident fund. Both the firms contribute an amount equal to the amount of the member's actual contribution during the year, and interest is paid. Faithful workpeople are also entitled to pension, and those who have completed 20 years' service at the Empress Mills get a special long service increment.

The welfare activities mentioned above are directly concerned with conditions inside the factory. It is proposed now to turn to those which deal with conditions outside the factory. Undoubtedly the most import of these is the provision of suitle housing. The Calico Mills havprovided workmen's dwellings (ch:s) for about 1,000 operatives in thrdifferent places. Messrs. Kirloskarros. Ltd. (district Satara) have fou:d a colony at Kirloskarvadi, wh most of their employees reside. As r as possible, every workman withis family is allotted separate qu:rs. Every house has a garden in nt which the owner has to keep in od condition. Electric light is prded, and most of the houses ha in addition, tap water. The recharged is 4 annas a month In Capore the British India Corpoion have provided very comfoble housing arrangements Two thand nine hundred and sixteen hes have been erected, and purely nmal rents are charged. There ahree types, namely, the single r with verandah, the single room w verandah and courtyard, and tllouble room with verandah and cyard. These houses are grouped itlements, which are well planted vtrees. Playing fields are situated c to these settlements, and are popular. At the same time an apt is made to build up a corte life for the dwellers in the ements. The welfare supervisor charge has undoubtedly conted to its success.

. the Buckingham and Carnatic . housing accommodation is pro-l at nominal charges for workmen dow pay. Extensive housing nes are being undertaken at shedpur, but very little mention ade of them in the Company's .t. Attention is, however, in-l to a new venture entitled a kagonal town." The labourers .oyed at the works are allowed uild huts in their own style, and huts are grouped together in orm of a hexagon. Several such ps have been erected. A small stian village has also been started, a church is under construction.

. the main, the outside welfare vities of many firms seem to have . entrusted to social agencies. The imbhoy Ebrahim Mills and the Mills have both entered into an ngement with the Social Service gue in Bombay to provide amenities of life for their workers. In this they have been able to secure the ices of men who are wholetedly interested in the work. y have started educational work providing day-schools for halfrs and night schools and training ses for women workers. They also have a literary society, debating societies, reading rooms and libraries. Recreation is not neglected. Sports and excursions are arranged, a cricket club has been started, and also an amateur dramatic club A small portable cinema has been bought and free shows will be provided. Wrestling is encouraged, and gymnasia have also been opened. The economic difficulties of the workers have not been overlooked. Co-operative credit societies have been started in connection with both sets of mills. It is interesting to note that the women in the reeling and winding departments have formed a co-operative credit society of their own.

Outside Welfare Work

The outside welfare work for the employees of the Empress Mills at Nagpur has been entrusted to the Young Men's Christian Association. A board of management directs these activities, half of the members of which are appointed by the Empress Mills and the remainder by the Young Men's Christian Association. Judging by the report, and by a personal inspection, the work is undoubtedly proceeding on right lines, and is filling a much-needed want. The employees are as far as possible encouraged to build up a community life, and to initiate and manage their own affairs. An institute situated in each settlement forms a common meeting ground, and it is not an unusual sight to see the children of a family studying in the school in the evening, the mother dropping into the girls' class to see how her daughter is progressing, while the father sits in the next room reading the newspaper, talking or playing some indoor game. Lectures and entertainments are given from time to time, and are well patronised. Games and sports of all kinds are encouraged, and a healthy feeling of rivalry is stimulated between the different settlements by arranging "inter-*basti*" competitions. The medical needs of the community are also not overlooked. A qualified Indian lady doctor gave her services gratuitously and also held a bi-weekly class for the *dais* of the *basti*. An eye specialist also paid periodic visits, attending to about one hundred cases during two months.

The various welfare activities at Jamshedpur cannot be described very fully, as only a brief report was submitted. Co-operative credit societies, co-operative stores, grain stores and

cloth stores are all achieving a large measure of success. Institutes have been established at different centres in connection with which there are night schools, dramatic clubs and libraries. A central athletic association has been formed, and football, wrestling, baseball and tennis are all encouraged. The Welfare Superintendent is an active member of all the various committees entrusted with looking after the general well being of the large community attached to Messrs. Tatas' Iron and Steel Works.

Such, then, are some of the attempts that are being made in different parts of India to provide amenities of life for those who have to earn their living in factories. One of the great drawbacks from which the workers suffer is illiteracy, but this, too, has received attention. The Buckingham and Carnatic Mills were the pioneers of the movement to provide education for their employees. They maintain an elementary day-school for half-timers and children of the workpeople, at which there is an average attendance of 500 in the morning and 500 in the afternoon. A technical school is run in connection with the day-school, where boys learn carpe[n]try, blacksmith work, fitting, hand-[lo]om weaving, and tailoring. There is [al]so a night school for adult operat[ive]s, and in connection with it techn[ica]l lectures are given in weaving, mac[hin]e drawing, electricity, and other [su]bjects. A recent report of the Gov[ern]ment Inspector of Schools testifie[s t]o the utility of the education provi[ded], and there can be little doubt that [the] whole hearted interest taken in it [by] the Joint Principals has helped v[ery] considerably towards the success [of] these schemes. The Calico and Jub[ilee] Mills, finding that the special edu[ca]tional needs of mill-workers have be[en] overlooked, have also opened scho[ols] for half-timers. Commenting on [the] physique of the children who atte[nd] these schools, they say : " Most of t[he] half-timers are physically very we[ak] and below the average weight; [in] fact, physically unfit to work [in] plants." The raising of the age [of] admission to factories from 9 to [12] was undoubtedly a much need[ed] reform. The British India Corpor[a]tion maintain two upper prima[ry] schools for boys and two low[er] primary schools for boys and girl[s] and have, in addition, two nig[ht] schools. Magic lantern lectures are given weekly in two settlements, at which special *parda* arrangements are made for the women, and prizes are given for the best essays on the lecture. At Jamshedpur there are 13 schools with 38 teachers, and an average attendance of 1,250 pupils. A special training class is held for teachers and the schools are highly commended by the Government Inspector of Schools. The Empress Mills contribute Rs. 1,200 towards some schools for Muhammadans and for children speaking Marathi. They have also offered to bear the cost of a commodious building if the Municipal Committee give land in a suitable locality.

From the above account it will be seen that many employers in different parts of India are whole-heartedly interested in the welfare of their workers. The All-India Industrial Welfare Conference provided the opportunity for collecting and distributing this information, and the permanent organisation that arose out of the Conference should in future form a convenient centre of reference for all those interested in the welfare movement.

The Institution of Productic Engineers

PRESIDENTIAL ADDRESS, OCTOBE 1922

By Mr. MAX R. LAWRENCE, M.I.Mech.E., I.A.E.

An interesting and instructive review o the Institution's history and future wor

IT is with much pleasure that I acknowledge the compliment you have paid me in again electing me your President for the ensuing year.

Last session saw the inauguration of the Institution, and I am pleased to say that during the first year we got well under way, and have had a very successful session.

Advance copies of the proceedings are here to-night, and each member will be in possession of his copy very shortly. The size of the volume, and the excellent matter which it contains, reflects a great achievement on the part of so young an Institution. It speaks well for the efforts made by the very large membership and the excellent work accomplished by you[r] Council and the Hon. Secretary. Th[e] state of our finances is sound, th[e] revenue has been more than ampl[e] to cover our activities, and th[e] Council have not been hampered by lack of funds.

Two provincial branches have bee[n] established, and are progressing very satisfactorily. These centres, which are at Newark and Coventry, are holding frequent meetings and having papers which, I think you will agree, augur well for the future. I hope that in the coming year several more local branches will be formed. I should like it to be generally known that twenty members are sufficient in the Council's opinion to form a [b]ranch, and that these local sections [ar]e entirely self-governing. They [ar]range their own meetings and [p]apers, have their own secretary and [co]mmittee, and the chairman has an [ex-]*officio* seat on the main Council of [th]e Institution. Each centre, at the [co]mmencement, budgets for its expenditure, and so far the budgets [ha]ve been very reasonable. The [ch]ief expense has been in connection [wi]th stationery and stamps, and [oc]casionally a small sum for the hire [of] a hall.

There is not the slightest doubt that [th]e movement which prompted your [Co]uncil and the original members to [jo]in this Institution is sound, and, [in] spite of all you may hear to the

contrary, there is plenty of scope for its activities. It is doing, and will do, very valuable work for production engineers that existing Institutions cannot do, or, at any rate, at present are not accomplishing.

During my tenure of office I have heard some doubts expressed, by men whose opinion I value, as to the usefulness of this Institution. Their idea, upon first hearing of it, was that a superfluous Institution had come into existence, and that its members could attain their object by joining one of the many institutions already established.

When I joined this Institution and assisted in its development, this thought had occurred to me, but when I attended your first meeting and looked carefully into the aims of its founders, I found that they were absolutely right, and that we were attempting to cover a field that was not being adequately dealt with by other Institutions. They also have their own field, which treats, in the main, with other phases of engineering problems. One has only to look at their proceedings and to take part in their meetings, to establish the fact that 99 per cent. of their papers and activities deal with the physical facts of nature and scientific phenomena underlying the designing side of the various engineering industries. In all probability not more than 1 per cent. of their activities deals with the actual manufacturing problems with which the production engineer is confronted in the translation of these things into the form in which they are of use to the community at large.

The various engineering institutions are accomplishing very valuable work, but these scientists and engineers would be powerless to serve the community by turning their knowledge to practical account unless they had also the services of a much larger body of engineers who are producing the things that they design, sufficiently rapidly and sufficiently cheaply to bring them within the reach of a very large number of people.

I will give two illustrations of the important part which production engineers play in advancing civilisation. In the early days, when it first fell to my lot to manage an automobile factory, motor cars were considered by the country at large as a nuisance. One frequently heard the expressions "that they should not be allowed on the roads" and "they were spoiling the country-side," and so forth. The maximum speed was limited to 12 miles per hour, and the taxation was heavy. A 10 h.p. car in those days cost anything up to £1,000, and it was a very poor machine, needing much attention.

This is in striking contrast to the position of the industry just prior to the outbreak of war, when it had been in the hands of production engineers for fourteen years. Motors were no longer a luxury, but a necessity of life, and a very good 10 h.p. car could be purchased for £170. The manufacturing organisations, machinery, and equipment had been much improved, and I make bold to state that this development was due more to the efforts of the production engineer than to the scientific side of the industry. I have heard it from many of my friends that it was the automobile industry and the steps taken by production engineers in the manufacturing of components that have entirely revolutionised shop procedure in other branches of the engineering industry.

I am now engaged upon the manufacture of wireless apparatus, this wonderful new invention undreamt of twenty-five years ago, but now placed within the reach of the proverbial "man in the street." In this connection delicate apparatus has to be manufactured in large quantities, and it may sound quite easy to the scientific engineer to make a condenser having a capacity of 0.035 Micro Farads, but I can assure you that it is quite another thing to make these in quantities of hundreds of thousands.

The measuring instrument is so delicate, and the current used so small, that the most sensitive telephonic apparatus has to be employed, and can only be used in a church-like silence. The hand of the operator must not approach within one foot of the standard because it has a capacity considerably greater than the tolerance allowable when approached, say, within three inches of the measuring instrument. It is true that the designers and the expert electricians realise these facts, but they have to rely upon the production engineers to make these devices in such a form that it is possible to multiply them in the time and at the price that will make an appeal to a very large public.

I think sufficient has been said to illustrate the point and to make you all appreciate the importance of the production problems that we have to tackle, which to us are even more important than the designs upon which we work.

Our scheme of society has set money as the common denominator to which we reduce the various values of services of individuals in the community. I have always maintained that the man who can lessen human effort and who can reduce the prices of commodities, serves his fellows equally as well as the man who, by employing his scientific knowledge, wrings the secrets out of nature to make life more congenial. Indeed, we hear on many sides that it is the designer and the inventor who usually receive the least recognition, and it is the man who translates his ideas into practice and sells them to his fellows who reaps the golden harvest.

Many of our works problems have to deal with the human aspect in industry. In producing things one has to employ numbers of people, and a great many brains are at work in lessening their efforts and so cheapening production, in designing and making automatic machines, and in adapting machines to new work. The organisations which are necessary in small works differ from those that are successful where a large number of people are employed. Each have their separate problems, and it is in the discussion of these that we are directing our efforts.

It is an essential qualification of a good production engineer that he should be able to turn the means at his disposal into producing the requisite output in the cheapest and best possible way. When this is analysed, it means that he is saving human effort and preventing waste.

Hence, the scheme of our Institution has been to follow on these lines. I, as far as my influence has been effective, have tried to make this Institution a means of bringing together a large number of people employed upon production. In my opinion, it is not essential that members qualifying for membership of this Institution should have had a particularly good scholastic education, as in the case of the larger Institutions such as the Mechanical, Automobile, and Civil Engineers. Also until recently these Institutions have not held many meetings in the provinces, so that to attend their deliberations meant, in many instances, the breaking of working hours and entailed travelling expenses, thus wasting time and money unnecessarily. I, therefore, think that a scheme for the establishment of a large number of small branches would bring about the greatest benefit to the membership.

There are many things in production that are of vital importance, and good results can be attained by their discussion that are not necessarily worthy of permanent record. It is right that people engaged in the control of workpeople in the same locality should know one another. The spirit of rivalry can be carried too far, and if there is established a channel for meeting to discuss matters of mutual interest much good will result.

In the provinces, and I hope now in London, our meetings will be less formal, and smoking will be allowed, and so there is an opportunity of spending a pleasant evening chatting over the problems of our daily life.

None of the institutions deals with the all-important subject of the psychology of human nature and its bearing on labour problems, but I sincerely hope that we shall have the courage to embrace this in our activities in the near future, as I think it is one of the most important matters with which we have to deal.

As questions of profit and loss have to be faced in any commercial undertaking, it is hoped that this Institution will not consider the discussion of costs and selling prices to be taboo, as this is yet another feature of our industry which is not treated by the larger Institutions. My own feeling is that the man engaged in a particular industry and earning his livelihood by producing and selling commodities such as automatic machine tools, is the person to whom we should listen when we wish to hear about such things, as he is giving his whole energies and attention to this problem. Such matters as the price at which goods can be produced and sold, the work they are capable of doing, and so forth, are best expressed by such a person. The ventilation of such subjects cannot be considered unsuitable or derogatory to the dignity of the Institution.

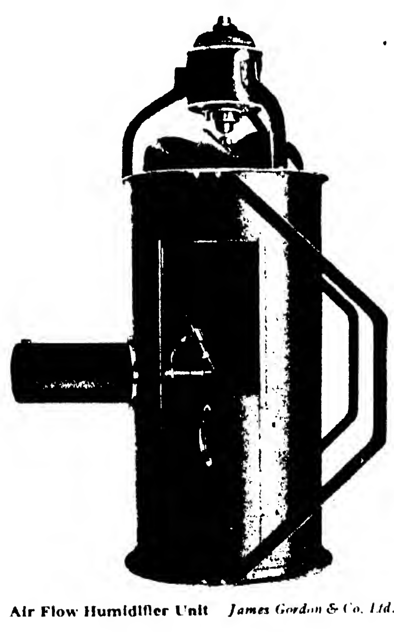
It is also highly desirable that the social side should not be neglected. Men engaged in production are often working early and late, and those of them who are fortunate enough to be employed in a busy industry had very little time in their struggle for life to spread their effort and indulge in recreation. It is very pleasant, therefore, to get to know them at informal meetings, and so increase our number of friends, and to exchange ideas to our mutual benefit and advancement. It also affords an opportunity for the younger men to learn, and I feel convinced, especially after a review of the past year's work, that we are on the high road to success. We shall be able, in spite of the suggested competition of other Institutions, to hold our own, to become strong and prosperous, and to do splendid work for our members and the community at large.

As I have previously pointed out, we are meeting the needs of an essential side of our industry which is not being effectively done by any other institution, and we are doing it cheaply and well. We are providing a means for the interchange of views and a means of education for a large body of engineers who are in control of the manufacture of products on which the whole structure of modern society stands. They are mostly men who have risen from humble circumstances, and have had to learn their profession in the hard school of life and experience.

The Air Flow System of Humidification

HUMIDIFIERS of the atomiser type have, during the past few years, come to the front again, owing to improvements made in the method of producing the spray or diffusing the particles of water throughout the air of the preparation or spinning room. In the air flow system manufactured by James Gordon & Co. Limited, London, two nozzles are employed, one projecting air, the other water, these nozzles being so arranged that an imperceptible spray of water is projected. Each humidifier unit is provided with a small motor (or rope) driven fan, by means of which the atomised moisture is distributed throughout the room to the fullest extent, thus securing evenness of humidification at all points.

A reference to the illustration will make the design of the apparatus quite clear. The compressed air and water nozzles are contained within a galvanized iron cylinder, to the end of which is fixed the small ⅛ h.p. fan. To the bottom of the cylinder is fitted a small water reservoir, the level in which is regulated by a float valve operating in the main water tank, from which each unit reservoir is supplied. It will be seen, therefore, that the water is under gravity, not pressure, and in the event of the compressed air failing, there is no trouble due to running water. The water nozzle carries a tube suspended below the level in the water reservoir, and the compressed air from the air nozzle sucks the water through this tube, at the top of which it is atomised.



Air Flow Humidifier Unit *James Gordon & Co. Ltd.*

It is claimed that this combination of atomiser and fan ensures the complete absorption of the water by the air, so that not even the smallest drops are formed, whilst the atmosphere is evenly humidified throughout the room. A further claim is made that 2.2 to 2.6 gallons of water per hour is atomised with 210 cubic feet of compressed air at a pressure not exceeding two atmospheres. Several large installations have been installed with unqualified success. In England one of the large Associations have adopted a very ingenious device for temperature regulation ; this application should be of particular interest for Indian conditions. It should also be noted that this system combines the functions of humidification with ventilation.

Railway Axle Box Bearings

Dealing with modern methods of melting bearing metal

THE following interesting details are given by the Monometer Manufacturing Company Ltd., who specialise in plant for the production of all kinds of bearings, and particularly furnaces and machines for the lining with white metal of the axle box brasses as used on railway rolling stock.

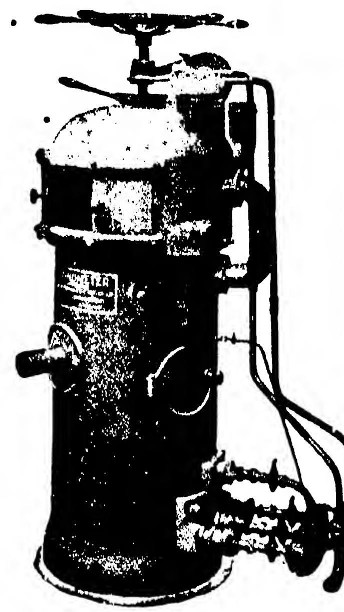
In Fig. I. is shown the patent white metal melting furnace made by this Company. It has many decided advantages over the old-fashioned pot heated by coal or coke, and they are now utilised by several of the large rolling stock makers in England for melting their white metal, and, in fact, are being used by practically all the firms who use white metals in any form, and many thousands of these furnaces have been installed during the past few years, and are gradually replacing the old-fashioned furnace.

One of their principal features is the automatic heat regulator which is fitted to this furnace. This instrument can be set to give any required temperature, and prevents the metal from overheating and burning. When dealing with an alloy containing tin and antimony, it is absolutely essential that the metal is not overheated, as these volatile parts of the alloy would be burnt out, and the life of the bearing seriously curtailed.

The furnace is arranged with a special anti-oxidization system, by means of which the surface of the metal is kept away from the oxygen of the air, and in this way a considerable saving is effected in dross.

When dealing with an alloy made up of metals with widely different specific gravities, it is found that these are liable to separate when the metal is in a molten state. A mixing arrangement is therefore fitted in the Monometer furnace, operated by a handle on the top of the furnace, and which is operated previous to withdrawing any metal. The metal is withdrawn from the pot by means of a valve, and in this way only the clean, gritless metal is withdrawn a most important point, and which prevents the journals from being scored.

Certain types of brasses can be lined on the Monometer die casting machine. This machine forces the white metal on to the brass, and the correct radius is formed by means of a steel die. With this method of production, no further machining is required, and this effects a further considerable saving in labour. It should be mentioned, however, that this method of production is only suitable for certain types of brasses, and the manufacturers of the machine are always prepared to advise whether the brasses can be lined in this way.

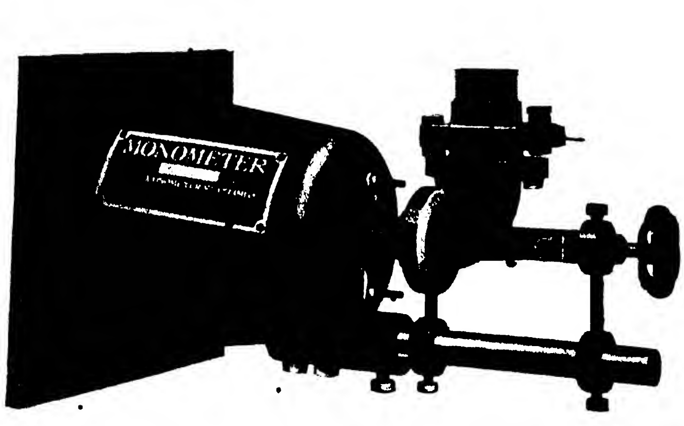


White Metal Furnace. Fig. I.

Another important apparatus manufactured by this firm is the heat-controlled oven which forms part of the plant usually supplied. Engineers dealing with the lining of brasses will no doubt appreciate how essential it is that the brass and the die or chill be at the right temperature for casting, and that this is made possible by means of these temperature-controlled ovens, which can be set to give any required heat.

The oven is also arranged with a sloping floor, so that they can be utilised for running off the white metal from old brasses. This metal is collected in an ingot mould arranged underneath the furnace, and can afterwards be re melted and brought up to specification. This is a much better practice than the one usually adopted of putting the old brasses into the pot of new metal.

These complete plants are in use in some of the largest naval construction works, rolling stock companies, and motor manufacturers, and have enabled perfect bearings to be produced with a regularity hitherto unobtainable.



Patent Oil Burner

TRANSPORT

Conducted by "M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH :: :: THE MANAGEMENT AND CONTROL OF RAILWAYS :: :: ::

Pneumatic Grain-Discharging Plant

Illustrations by courtesy of Messrs. Henry Simon Ltd.

A TRAVELLING pneumatic grain discharging plant has been installed by Henry Simon Ltd., the well-known grain handling engineers, Manchester, for use in connection with the Meadowside Granary, Glasgow. The elevator, which has been erected on the quay in front of the Meadowside Granary, is intended to work in conjunction with the two existing travelling ship discharging bucket elevators. The pneumatic plant has a capacity of 100 tons per hour, and it will be used for working in awkward positions of a ship's hold which are inaccessible to the legs of the big bucket elevators, and also to assist in discharging grain from the main holds.

Travelling Pneumatic Discharging Plant

In order to permit the pneumatic plant to work either independently or in conjunction with one or both of the bucket elevators, it is necessary for the position of the plant to be changed on the quay relative to these two elevators. To do this a special side traversing equipment is provided, and rails are laid at right angles to the main track, so that the pneumatic plant can be traversed into a siding while the bucket elevators pass. The side traversing of the pneumatic plant is effected by four mechanically operated screw jacks, by means of which the whole of the structure is lifted bodily from the rails, thus permitting the bogies to be swung round at right angles, so as to engage with the rails running into the siding. The whole plant is then lowered again on to these rails, and run back out of the way. The elevator can also be traversed along the quay at a speed of 60 feet per minute, so that it is quite an easy matter to move the plant from hold to hold as required.

The elevator is mounted on a steel structure running on the same rails as the bucket elevators, and has a wheel base of 20 ft. by 20 ft., and a structure base of 32 ft. 4 in. The height of the elevator is 65 ft. 6 in., and its total weight is 110 tons, exclusive of grain.

The Control Cabin

The control cabin is of similar construction, and extends outward in

the front of the structure. It is arranged high up, so as to give the operator an uninterrupted view of both the ship and the quay. The cabin is carried on special joists and columns fitted into the front of the structure. The structure is lighted by Hope's steel frame casements. The crane post is mounted on the top of the structure, and is of the steel angle braced type, mainly composed of 3½ in. by 3½ in. by ½ in. angles, with 2½ in. by 2½ in. by ⅜ in. bracings. The structure is also provided with various supports and brackets for carrying the tackle gear operating the grain pipes.

General Construction

The main structure, as already mentioned, is mounted on four double-wheeled travelling bogies, geared to give a speed of 60 ft. per minute. The main road-wheels are of cast steel, double-flanged 2 ft. 6 in. in diameter, and are mounted on 6 in. shafts. The wheels are driven through centrally disposed steel bevel gearing operating steel straight cut gearing for revolving the road wheels. This gearing is fitted on two bogies at opposite corners only. The bogies proper are carried in pivot bearings, built into the main structure of the Warren girders, and the brackets carrying the bogies are hinged to take up unevenness on the rails, thus bringing the contact surfaces down to a minimum. The shafting operating the traversing gear is carried vertically up from the two bogies to further sets of steel bevels which operate across the structure, and are brought to one point on the first floor, where they terminate in spur gearing driven by a 30 h.p. motor, running at 500 r.p.m. The coupling of the motor is fitted with a solenoid break.

The screw jacks for lifting the structure have split cast steel bodies, and are bolted one to each corner of the structure. The shoes slide in the castings on feathers, and are screwed inside 4 in. diameter ⅞ in. pitch. Immediately on top of each jack is a spur wheel and vertical shaft, which is operated by means of horizontal shafting and steel bevel gearing. This shafting, from the four jacks, is brought to one point on the first floor of the main structure, and is operated by steel spur gearing by a 10 h.p. motor running at 500 r.p.m.

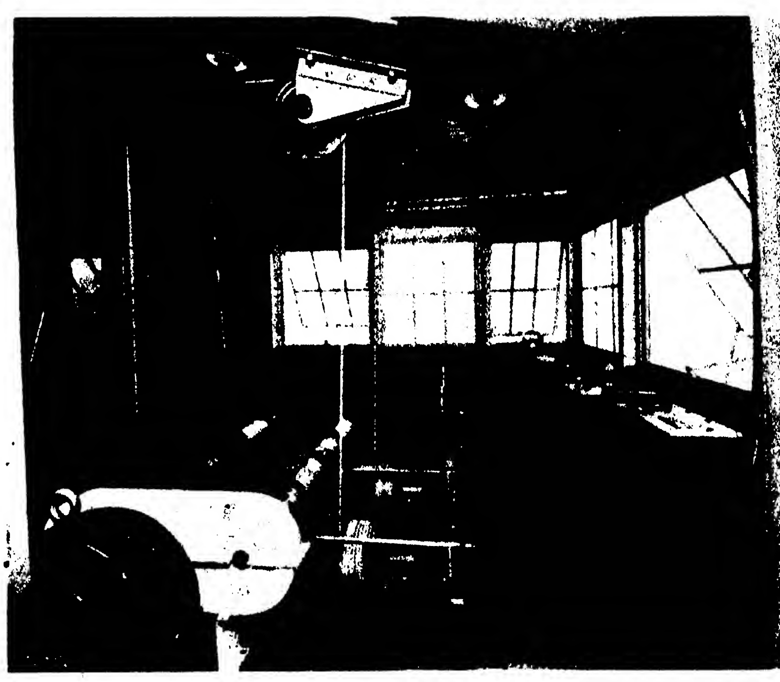
The Exhauster

On the first floor of the structure is also situated the main exhauster and motor. The exhauster is by Messrs. Reavell & Co. Limited, of Ipswich, and is of the "Turbo" rotary type, driven through gearing which increases the speed from 500 r.p.m. on the motor to 3,500 r.p.m. on the exhauster. The power of the motor is 180 h.p., and the whole plant is automatically controlled. Should a choke occur at any point, the motor is immediately cut out. Forced lubrication by pumps driven off the main shaft is provided for the exhauster. The air-suction pipes are of welded mild steel, and are carried to the air filters on the top deck of the structure. These filters are steel cased with fabric sleeves, and mechanically-operated shaking mechanism, and can be cleaned during the running of the plant by closing the valves on any one filter. The grain dust taken out by these filters is passed through rotary seals of the adjustable type, which discharge the dust into worm conveyors. The whole of the gearing for dealing with the dust is driven by a 5 h.p. motor operating through silent chain drive. The same motor operates the tipper which discharges the grain from the grain receiver.

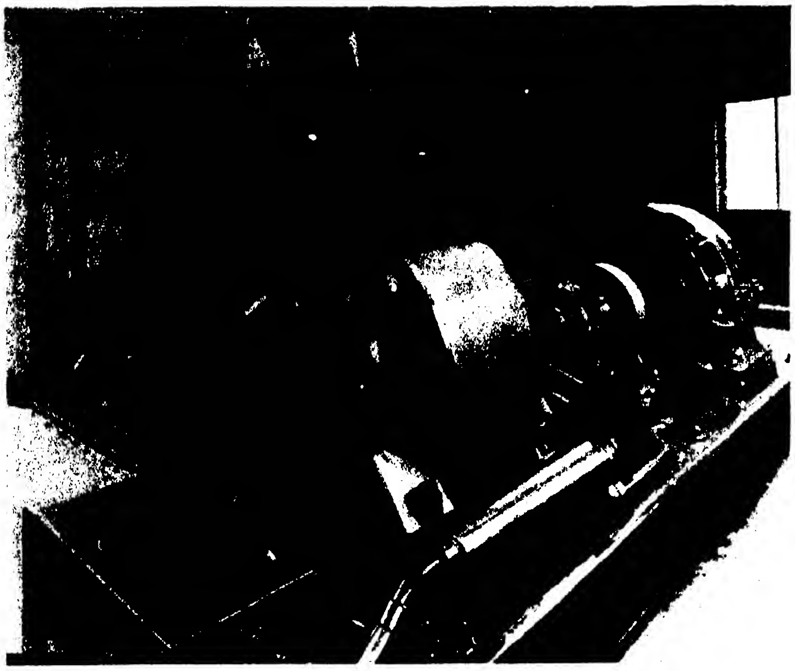
The grain is drawn from the ship to the grain receiver through flexible lengths of steel piping fixed to a telescopic length in each vertical piece. These pipes being telescopic, it is an easy matter to adjust the length of the pipes to suit the rise and fall of the ship, or the fall of the grain in the holds. There are two intake pipes, and the pipe-booms are of weldless steel construction with rectangular bends at their outer ends and flexible connections, as shown in the illustration. The pipes terminate in ball and swivel socket joints, which permit of the pipes being lifted up and down, or slewed through a considerable radius, thus facilitating discharge from the holds. At the intake end there is a "Reform" patent nozzle fitted with an auxiliary adjustable air inlet. The adjusting gear for the pipes is arranged in the control cabin, and is composed of a "Multiple" drum winch of four units, operated by one 5 h.p. motor running at 500 r.p.m.

Delivery of Grain

The grain is carried up the intake pipes and delivery to the grain receiver, and is discharged through a Simon patent tipper which is mechanically operated, and is provided with a special mechanism to prevent damage in case of any solid body becoming jammed between the cross bar of the tipping-box and the lip of the seating.



View in Control Room



The Rotary Exhauster

The grain released by the receiver passes to an Avery 4,000 lb. automatic weigher, which is provided with all the latest improvements for regulating the feed and registering the loads and quantity passed through. The weigher is also fitted with a residue mechanism for weighing any small parcels. The grain then falls into another hopper arranged on the first floor, and thence through telescopic pipes to the bands beneath the quay, or alternatively to portable bands which carry the grain under the pneumatic elevator to the transit sheds. A 15 h.p. motor has been installed for operating these bands. The electric power is carried from the plug boxes along the quay by means of a portable cable wound on drums arranged on the structure.

The International Association of Navigation Congresses has selected London for its next Congress in 1923.

Modern Blast Furnace Practice

At the autumn meeting of the Iron and Steel Institute, held at York, the most important paper from the general engineering point of view was that of Mr. A. K. Reese, entitled "The Basis of Modern Blast Furnace Practice," and although Mr. Reese had very little fresh to say, there were one or two points of interest, especially in the discussion. He laid great stress on the necessity of having the materials of the blast furnace, the coke, limestone, and ore, in as uniform a size as possible, so as to get a homogeneous mixture and keep down the amount of molten slag, which, of course, represents a serious heat loss.

The discussion passed on to the part played by the porous properties of coke, and the work of Messrs. Sutcliffe & Evans in the preparation of hard carbonised briquettes, which are claimed to give results equal to the old charcoal. It is a remarkable fact that modern blast furnace practice has got down the amount of coke used to about 16 to 17 cwt. per ton of pig iron, as compared with the average figure, not so many years ago, of 25 cwt. per ton. As is well known, the elementary theory with regard to the chemistry of the blast furnace process is that the limestone is decomposed, giving carbon dioxide gas, whilst the free lime unites with the silica present to give molten slag. The carbon dioxide is then reduced to carbon monoxide by the mass of white hot coke, and this carbon monoxide then in turn reduces the oxides of iron, that is, the iron ore, to metallic iron, being oxidised again to carbon dioxide. The theoretical amount of coke required, according to this series of reactions, is about 20 cwt. per ton, and there is no adequate explanation as to why much less than this can be used. In the old days, when charcoal was the only fuel, the amount used was very much less still, being not much more than about 10 cwt. per ton of iron, whilst the quality of the old charcoal iron has never been equalled by the modern coke product. There is no question that the mechanical properties of fuel play a very great part in the matter and charcoal is so valuable because it is extremely porous, so much so that what chemists call "surface combustion" takes place in a way that is not possible with coke.

Messrs. Sutcliffe & Evans claim that their carbonised briquettes have practically the same mechanical properties as charcoal, and they expect to be able to reduce the quantity of fuel used to not much more than in the case of charcoal.

It may be remarked, also, that the discussion showed very clearly how rapidly the old monster, cumbersome, slow-speed blower for the blast furnace is being replaced by the modern steam turbo-blower. Now that the problem of delivering greatly varying volumes of air at a constant pressure has been overcome by the invention of improved methods of governing, the turbo-blower has of course every advantage, both in price, small weight (and consequently smaller foundations), much less floor space, absolutely continuous delivery of air without reversing, and less liability to breakdown, in spite of the high speed.

How the Roadrail System Solves the Transport Problem

Recent important developments in connection with the Loco-Tractor have rendered this mobile Power Unit of greater utility, and the many successful applications of the system point to its more extensive use. The present article, written by a Transport Expert, discusses the subject from various points of view, and outlines probable future tendencies.

IT is somewhat late in the day to make claims as to the utility of the loco-tractor, or the road-rail system, as a useful transport medium. The practicability of the system, and its exceeding advantages both for road and rail conveyance, have long been proved, and clearly proved, in various parts of the world. As, however, in connection with the forthcoming British Empire Exhibition, to be held at Wembley, on the outskirts of London, the road rail system has been installed and has, in fact, been regularly at work for many months, it may be of interest briefly to describe the arrangement there, and, at the same time, to outline the many advantages the system possesses.

Special Claims

That certain classes of transport work, and those on a wider scale that would appear possible at first sight, can more economically be performed by the loco-tractor than by any other medium is generally admitted. It cannot, and does not profess to, constitute a rival to the railway *qua* railway for long-distance haulage, nor does it claim to be a superior unit to the modern motor vehicle for road transits of any length. What, however, it does claim and all those who have been privileged to witness the actual working of the roadrail system are convinced the claim is a valid one —is that, in pioneer transport, or for the arrangement of a composite service by road and rail, the loco-tractor possesses advantages beyond those of any other haulage unit.

Both in Great Britain and other countries, where railway development is far more extensive than is the case in India, there has long been expressed the definite need for some more simple form of transport than that provided either by the modern railway or the motor vehicle which, for effective work, requires specially good roads. In particular it is necessary, if agriculture is to be developed to greater possibilities, for some means of transport to be adopted that will, with due regard to the work to be performed, function at a cost within the limits of the traffic adequately to bear. It is, in fact, not too much to say that the arrangement of cheaper transport in districts not provided with railway communications or with good roads is not merely a National or Empire problem, but a world-wide one.

As I said in a previous article dealing with "The Loco-Tractor as a Transport Medium," production is stimulated or discouraged in almost direct ratio to the cheapness and regularity of transport from the point of production to the ultimate consumer, and railways cannot possibly meet the full, the whole need. It would not be practical politics to build expensive railways into hitherto untapped districts in the vague hope that traffic would be so encouraged, that in due course the enterprise would be profitable. It is necessary, then, to consider less expensive means, such as feeder lines, road transport or other methods of traction. During the last few years, Indian capital has helped materially towards the development of transport facilities by the construction of feeder lines tapping districts hitherto distant from modern communications, and it would seem that progress in this way is one of the great future requirements. But feeder lines, of the ordinary type, cannot cover the whole ground, and, from all indications, it would appear that the new loco-tractor idea, developed in South Africa as a direct result of war conditions, will be the means of solving what has been termed the "pioneer" transport problem.

Description of the Loco-Tractor

The new form of locomotion, known as the Roadrail System, which overcomes many of the disadvantages of light railways, and, moreover, furnishes road transport as well, utilises as a prime mover a loco tractor, the driving wheels of which run on tracks laid alongside the rails, increased adhesion being obtained on the wheelway by the use of solid rubber tyres. In other words, the fundamental principle upon which the invention is based is the low tractive resistance of vehicles running on rails as compared with the high tractive resistance of vehicles running on roads, and, correlatively, the high tractive effort obtained by using solid rubber-tyred wheels running on roads as compared with the low tractive effort of locomotives running on rails. This result is obtained by running the driving wheels of the tractor either inside or outside the rail track on wheel ways formed of concrete, macadam, or other suitable material to make a roadlike surface, while the vehicles hauled run on the light railway track. The co-efficient of adhesion on the wheel-way is up to 1,350 lb. per ton of adhesion weight, as compared with, say, 450 lb. per ton in the case of an ordinary locomotive running on rails.

A distinct additional advantage is to be found in the fact that only light section rails are required. The primary necessity for heavy rails lies in the need for an adequate road to support the locomotive, and as in the roadrail system the major portion of

the weight of the prime mover is carried on the wheel-way, the only weights imposed on the track are the carrying wheels of the tractor and the vehicles accommodating the traffic forming the load. Suppose, for example, a tractive force of 5,000 lb. at the rail or road surface is desired, this value can be obtained in the case of the roadrail system at the surface of the wheel way with one axle, with a loading of about 4 tons, while a relatively light machine whose carrying axles run on the rails will only carry about 2 tons per axle. On the other hand, it would be necessary to

The high cost of permanent way construction and maintenance in the case of the ordinary light railway is well-known. The roadrail system, on the other hand, requires such a light form of track that the Decauville type of about 16 lb. per yard will suffice to take an axle load of two tons. The general construction cost of roadrail track averages between 15 and 20 per cent. of the cost of ordinary light railway track for the same purposes. It should further be added that, while ordinary light railways are generally limited to gradients of 1 in 40 and curves of about 150 feet

locomotive, and (4) no fuel is consumed except when useful work is actually being performed, while high tractive effort, combined with low tractive resistance, reduces the haulage costs to a minimum. Consider further the comparison with the road motor vehicle, where much of the advantage of high tractive effort is lost by the high tractive resistance due to the load. In this case, in terms of useful work, a single roadrail train will take a load equivalent to that taken in sixteen motor lorries, the latter requiring sixteen vehicle crews, and entailing high fuel and

Roadrail Tractor in Operation.

have about 11 tons on the driving axle, with rails of heavier section to suit, in order to obtain the same traction from an adhesion locomotive running on rails. Thus it is manifest that the roadrail system combines the advantages of the light railway and the motor-lorry at a lower initial cost of construction and equipment, and a more economical cost of operation than either of these individual systems.

radius, the roadrail system enables gradients up to 1 in 12 to be surmounted, while curves of 30 feet radius are easily negotiated.

The running cost of the system is, then, extremely low for four main reasons: (1) to the interest on the low capital outlay, (2) to the low maintenance cost of the track, (3) the economy of staff in that only one man is required to drive a tractor as against two men on an ordinary

tyre expenditure, together with heavy depreciation.

Two other points should be noted before reference is made to the roadrail system in operation. One is that, as already intimated, the loco-tractor may be adapted to run on rails and road alternatively, and in its various types may be driven by internal-combustion engines, by steam, or by electricity. The fuels used may be petrol, paraffin, alcohol, crude oil,

gas, or producer gas, and for the steam type coal, firewood or other fuels. The second point is that, owing to the relatively low cost of installation, the road-rail system is eminently suitable for temporary purposes, as, unlike the ordinary railway, the transference to another site is not an expensive proposition.

The First Roadrail Installation

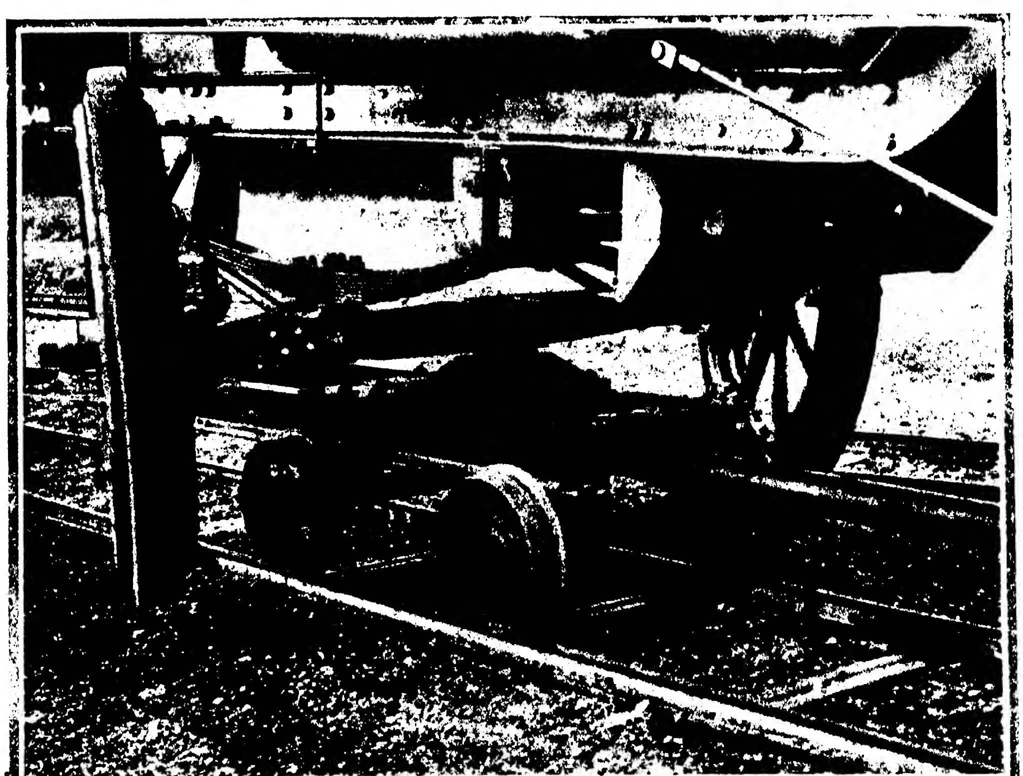
The loco-tractor was the invention of a South African engineer, and it is not surprising, therefore, that it was first tried out in that country, where the possibilities of its extensive use are profound. The first track on the roadrail system was laid by the South African Government Railways Administration, primarily for experimental purposes, and was designed to put the system to the most extreme tests. To this end, at the installation near Johannesburg long gradients of 1 in 17 and 1 in 18 were used on the straight, the sharpest curves were 37 feet radius, and there was a balloon curve of 50 feet radius. Additionally, on one 100-foot curve there was a grade of 1 in 18, equal to 1 in 14 on the straight. The rails used were 16 lb. section, with 6 lb. light steel sleepers, while the loco-tractor weighed 4½ tons, and was fitted with a 35 h.p. engine using paraffin as fuel.

These trials proved conclusively that the principle of propulsion was a sound one. The locomotive rode easily at 18 miles per hour, and took 30-ft. curves steadily at about 12 miles per hour. After 2½ years' work the rubber tyres of the tractors were in good condition, being worn down half an inch evenly all round.

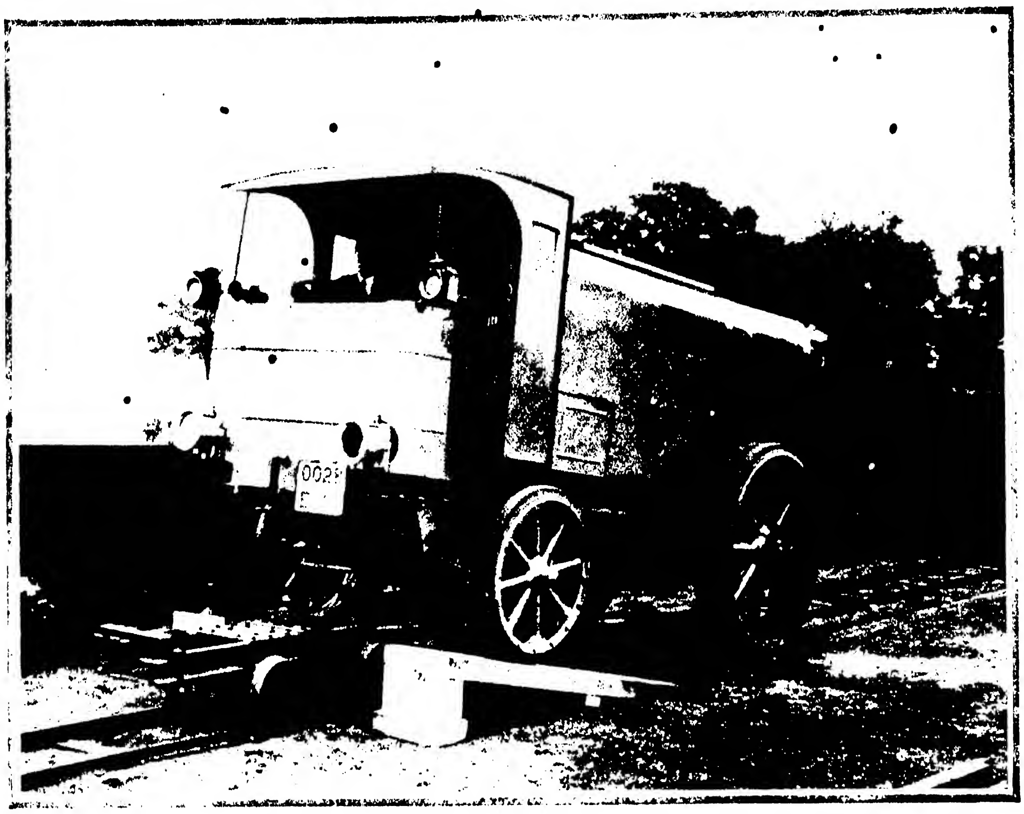
Subsequently a series of highly successful trials were run in Uganda, and one of the leading journals in that country, after remarking that the 4 miles between Kawempe and Kampala had been covered in 12 minutes, stated that the roadrail system would probably prove to be the solution of the transport problem in the Protectorate. Since that time, 50 miles have been completed on this useful system, and a further 400 miles are in contemplation. Dealing very definitely with the utility of the road-rail system, the Governor of Uganda recently stated that he had seen no reason to alter his original optimistic opinion as to the value of the new form of transport. He added that the total cost of installing the system between Kampala and Kalule, 26 miles, when in full running order, would be £31,000, or £1,200 per mile. It is understood that great developments are pending in Uganda, while special attention is being given to the performances there by the Gold Coast Legislative Council, as it is considered highly probable that the roadrail system will prove extremely useful in connection with the transport needs of the cocoa industry.

Other Countries

As for other countries, a short commercial line has been opened in Scotland, and another is in progress, while the interests that have acquired the concession rights for the roadrail system in Roumania and Spain (including



Details of Front Axle



Method of Mounting Front Axle Bogie

Spanish Morocco) are developing the system, and have in several places got loco tractors in successful operation. Incidentally, it may be added that the system has been extensively used by the Spanish War Authorities in connection with the campaign in Morocco.

The Wembley Installation

In connection with the British Empire Exhibition, to be held at Wembley, on the outskirts of London, Roadrails Limited obtained permission to provide an installation of their system of transport, the limiting condition being that no trees should be cut down. I say "limiting," though that is hardly correct, as, owing to the extraordinary mobility of the system, the laying of the track under the conditions indicated does not detract in any way, save perhaps that of speed, from the utility of the transport medium. The track, as laid, includes curves of 35 feet radius and loops of 50 feet and 75 feet radius, while there is a gradient of 1 in 14½ on the 50 feet radius curve, which naturally increases the tractive effort required from the transport unit.

The tractor doing duty at Wembley at the time of our visit was of 50 h.p., and while this presents an imposing appearance, and has an appearance of great strength, it is quite simple to control. Hauling a load of 16 tons, the tractor experienced no difficulty at all in negotiating the steepest gradients and sharpest curves, and its ease and flexibility were especially manifest. To change from rail transport to road haulage is the work of a moment. The front wheels of the tractor (the actual wheels, and not the bogie wheels for rail haulage) run up a double ramp, the bogie is then pushed away, the larger wheels run down the ramp, and the big vehicle turns off and proceeds as a road unit.

Exhibition Demonstrations

In addition to the handling of freight traffic, it is intended during the run of the Exhibition to give demonstrations of passenger-carrying by this new medium, and it would seem that this will have the effect of popularising it to an extent that is bound to aid the fuller development of this most useful method of transport. Messrs. Roadrails Ltd., whose offices are at 1 Dover Street, Piccadilly, London, W.1, are willing to send full information regarding the most recent developments to all interested parties, and in view of the undoubted advantages of the roadrail system, we feel that in due season their enterprise is bound to reap an abundant reward.

OMISSION

In our last issue we regret that we made the following omissions :—

Our frontispiece was by the courtesy of Messrs. The English Electric Co. Ltd.,

The illustrations used in the article on the Duplex-Mono were by courtesy of Messrs. Chapman & Hall.

Steam Railroad Electrification

Address presented before the Western Railway Club, Chicago, by S. B. Cooper, General Engineer, Westinghouse Electric & Manufacturing Company.

MUCH has been said regarding the results obtained on particular installations by means of electrification. There have been heated discussions held regarding the relative merits of steam and electric locomotives as machines. Volumes have been written on the subject: "System of Electrification—Alternating *versus* Direct Current, Low *versus* High Voltage, Overhead Trolly *versus* Third Rail."

Let us to-night approach the subject of electrification from a little different angle. Let us begin with certain fundamental assumptions, accepting them temporarily at least as facts, and thus avoid travelling over old ground.

Let us assume, first, that electrification *has* accomplished much in the particular installations of which you have all heard. Second, that we are in complete agreement that steam and electric locomotives are both remarkable machines, highly developed, both undergoing constant improvement, and both destined to accomplish great results in their respective fields. Third, that electrical operations may be satisfactorily accomplished in a number of ways, differing in detail, each having its ardent advocates and opponents, but, after all, each successful in actual service under existing conditions to a remarkable degree.

With this background established, then, what can be said for and against electrification?

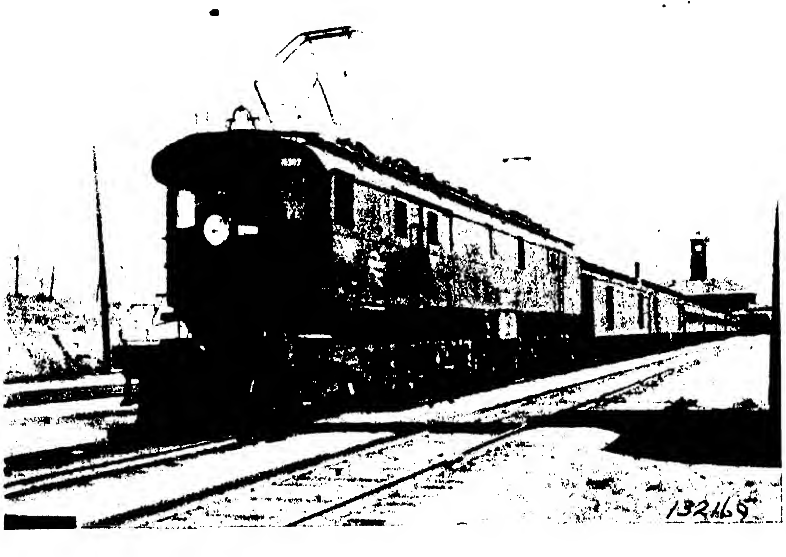
The only possible objection to electrification is the large investment required.

This objection can be sustained only if it can be shown that electrification fails to effect economies sufficient to pay a satisfactory return, or that the same capacity for moving traffic could be obtained at lower cost by other means. Each particular case must be considered on its merits, and all of the factors considered. Obviously, only those roads or parts of roads will be electrified where it can be shown that one of two conditions exist:

(1) Either a given limitation can only be overcome by electrification, as in the case of long tunnels, etc., or

(2) A given traffic capacity can be obtained by electrification with sufficient operating economy over steam to justify the extra investment.

Fifteen or twenty years ago, when electrification first came up for general discussion, enthusiastic predictions were made by some electrical men that the steam railroad was about to be retired, much the same as many auto-'bus enthusiasts to-day say that the auto-'bus will supplant the electric street car. As time went on, and the electrical engineers acquired a better knowledge of railroad methods and problems, and as the railroad operators learned more of the possibilities of electrical operation, we have come to a firmer common ground of understanding and a more respectful attitude towards each other's viewpoint. No one to-day would be so rash as to predict the early retirement of the steam locomotive, or the prospect of the immediate electrification of a very large part of the railroad mileage of the country. There is, however, a very general acceptance of the fact that electrification is firmly established in certain fields. That the use of electric power offers to the transportation industry a new tool—a tool that permits, because of its characteristics, new operating methods and the ultimate accomplishment of results apparently impossible with previous means.



4,000 H.P. Baldwin Westinghouse Locomotive

These fields may be outlined as follows:

(1) Congested terminals in large cities, often involving tunnel approaches.
(2) Heavy suburban service.
(3) Heavy grade divisions carrying dense traffic, and, under existing operating methods, limiting the carrying capacity of a whole system.
(4) Sections remote from suitable fuel supplies, and where abundant hydro electric power is available.

The industrial expansion of this country has been phenomenal. No one doubts that this expansion will continue. For reasons too familiar to require discussion here, the railroads of the country have not kept pace with the growth of our population or our industrial and agricultural activity. While the immediate future may appear doubtful, adequate transportation is too vitally necessary to our national welfare to permit politics, labour disturbances, financial depressions, or other agencies to interfere with the ultimate progress and prosperity of the railroads of the country. If this is true, may we not logically look for an increasing demand, and an absolute necessity for increased traffic capacity? In looking for ways and means of increasing this traffic capacity most economically, we must realise that changes and continued improvements in operating methods are inevitable. Shippers and consignees will find means of more promptly loading and unloading cars, perhaps involving a pick-up and delivery service. The railroads will find means of handling trains between major terminals without delays and re-classification at intermediate points. They will find means of moving these trains in larger units and at higher speeds than now customary.

It does not seem unreasonable to expect that train sizes will be limited only by the strength of the draught gear, and speeds only by alignment and car journal performance. As the need for larger trains and higher speeds increase, who can say that means will not be found to overcome these limitations?

In the electric locomotive we have available a motive power unit able to produce, under the control of one operator, as great a tractive effort as the strength of the cars will permit, at any speed considered safe for the alignment of the road and for the satisfactory operation of the car journals. Experience with electric

Baldwin Westinghouse Locomotive, 6,000 Volts. DC.

locomotives to date has proven that they are extraordinarily reliable, relatively cheap to maintain, and available for service a very large percentage of the time. When properly designed for the service to be performed, and when operated within their rated capacity, the routine inspection and running adjustments can be made in a very short time, and the percentage of time in the hands of the mechanical department is very small. I just recently heard of an example that will illustrate my meaning. An electric heavy inter urban railroad operates two sixty-ton locomotives in coal hauling service. They are coupled together and operated as a unit, and for months past have been in service 24 hours a day, except for four hours once a week, when they are inspected and the necessary renewals and adjustment made.

The freedom from the necessity for stopping for coal and water is in itself a great advantage on a busy track, particularly where heavy trains are operated with more than one engine per train. The absence of boilers to be washed, and fires to be cleaned, makes through runs over two or more divisions possible. The higher speed available with electric motive power increases the possible length of operating districts, and often the elimination of intermediate terminals.

Regenerative braking has proven itself an immense advantage in heavy grade operation. The saving in power, wheel and brake shoe wear, delays and damage due to stops to cool wheels, while attractive in themselves, are all overshadowed by the increased reliability and safety of operation. Air brakes are held in reserve for use in emergency, and for coming to a complete stop.

Electrification has revolutionised tunnel operation. In the Elkhorn tunnel of the Norfolk and Western Railroad, bad rail conditions due to condensation, and the difficulties due to smoke and gases, steam operated trains commonly took thirty to forty minutes to clear. The electrically-operated trains now clear in about 2½ minutes, and so far as the operation of trains is concerned, the tunnel may be considered as non-existent. The same relief has been experienced in the operation of the Hoosac tunnel of the Boston and Maine, the Sarnia tunnel of the Grand Trunk, the Detroit tunnel of the Michigan Central, and others.

In suburban service the multiple unit trains offer the marked advantages of higher schedule speeds due to higher accelerating and braking rates, more uniform schedules due to the maintenance of a constant ratio of motive power to train size, and increased facility of handling due to double end operation. An analysis of steam suburban service shows generally two operations for the electric motor car train—one in and one out.

The steam train requires several engine and train moves. It has been the practically universal experience of roads that have electrified their

suburban districts, that the faster, cleaner, more reliable service has attracted greater patronage and built up income. Hence electric operation opens up an opportunity to transform a necessary service from a burden to a source of added income.

Another field that offers attractive possibilities, if electrified, is that of branches and feeder lines in growing and productive territory. Such lines may be electrified following interurban practice, thus forestalling other electric line or auto-'bus competition, and by means of improved service, building up a very profitable traffic. There are undoubtedly a great many such lines in the country. The experience with the "safety car" on city systems has indicated the marked effect on traffic of frequent rapid service. The amount of business now being handled by gasoline 'buses and trucks is surely sufficient indication of the existence of business that might be profitably handled by the railroads if they would provide the proper equipment and facilities for its accommodation.

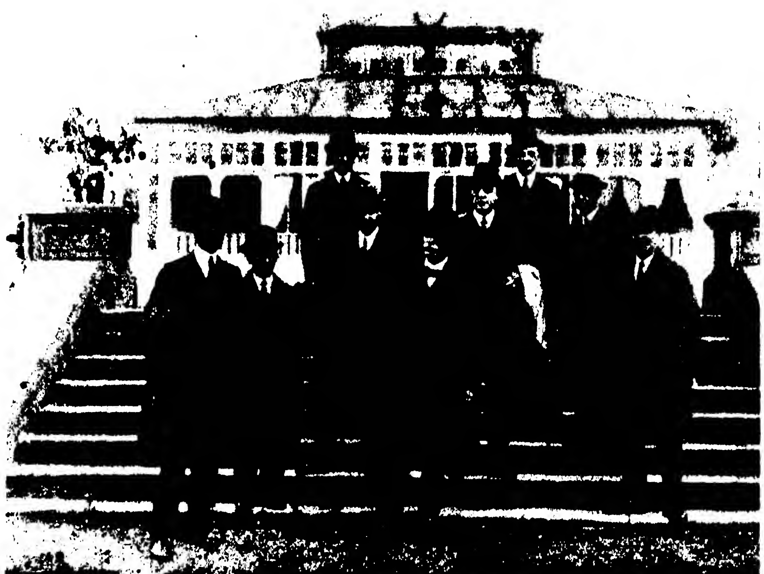
We have briefly reviewed the possibilities of electrification, and have seen these pictures of electrical operation of various kinds of service.

In concluding, I would like to emphasise a feature that seems of vital importance. In the electrification of other industries, economies in fuel, labour, maintenance, sanitation, etc., while in many cases important in themselves, have been subordinate to the advantage of increased production.

Statistics show that our freight traffic doubles in about twelve years. Our transportation machine has had great difficulty in producing 450 billion ton miles in recent years. What is it going to do under a load of 900 billion ton miles by 1930 or 1932? Electrification is bound to be a big factor in the solution of the problem, and therefore justifies the co-operative study and development of both the railroad engineers and the manufacturers.

India and the British Empire Exhibition

At the forthcoming British Empire Exhibition, to be held at Wembley, near London, India and her industries are to be represented on a substantial basis. The Indian Pavilion is to be erected on the site of the Golf Club House shown in the accompanying illustration, which also depicts a number of traffic and excursion agents from the leading British railway companies who will be specially concerned with the transportation requirements of the Exhibition. On a recent occasion, these gentlemen visited Wembley, and were shown round the grounds by Colonel Tempest Stone (back row, left-hand side), so that they might be in a position to make adequate arrangements not only for the conveyance of the exhibits, but also for the transport of the millions of people who will visit the Exhibition. As we go to press, we learn with interest that the Finance Committee of the Indian Legislative has sanctioned a credit of £113,000, the estimated cost of the Indian Pavilion. The Exhibition Commissioner will return to England from India in April.



Representatives of British Railway Companies Inspecting Exhibition Site

SCIENCE

Conducted by A. H. HAVER, M.I.N.A. & K. S. DICKINSON, F.C.S.

THIS SECTION DEALS WITH THE APPLICATION OF SCIENCE TO INDUSTRY AND PARTICULARLY DEALS WITH APPLIED CHEMISTRY

Synthetic Chemistry

THE theories of molecular structure may be regarded by some people as of little practical importance, and could scarcely come at all into direct touch with the daily life of mankind. And yet, these theories form the very basis and foundation of some of the greatest industries of the present day! Kekule's dreams, perhaps, were an interesting psychological phenomenon, but the stuff that his dreams were made of, the theories of molecular structure, were as important for the advance and development of organic chemistry, as a chart and compass are for a mariner. For the purpose of a scientific theory is not merely to explain or co ordinate knowledge already acquired, but also to be a guide to the exploration of the unknown; and without the theories of molecular structure or constitution put forward by Kekule, van't Hoff and Le Bel, there could not have been built up that vast structure of organic chemistry such as we know it at the present day, nor could we have witnessed that crowning achievement of organic chemistry, the artificial, synthetic preparation of many of Nature's own products, from which has developed the industrial production of those innumerable dyes, therapeutic agents, perfumes, and other materials, which are regarded as necessaries in our modern civilisation.

But while the theories of molecular structure and constitution gave the guidance necessary for the altogether phenomenal development of organic chemistry during the past sixty years, that development could actually take place only through the genius, the energy, and the persistence of hundreds of zealous workers who devoted themselves to the task of synthesising and elucidating the constitution of thousands of organic compounds, and it is therefore only natural that it is in that country Germany which, amongst all other countries, has been conspicuous for its recognition of the importance of such investigations, and for the encouragement which it has given to them, that we find the industries dependent on synthetic organic chemistry chiefly flourishing.

Not only has the chemist discovered numberless compounds hitherto unknown, but he has even entered into competition with Nature herself, and has successfully broken the monopoly which heretofore she had enjoyed in the production of many compounds both of ornament and of utility. In fact, so successful has the chemist been, that not only can the artificial products, in a number of cases, compete with the natural products, but they have even driven these entirely out of the market. In this way great industries have arisen, of which the most important are those closely interdependent industries which find their raw materials mainly in coal tar, and it is to these that we shall first turn our attention.

By the distillation of coal there is obtained not only the gaseous mixture so largely employed as an illuminant, but also considerable amounts of ammonia and a thick, dark-coloured evil-smelling liquid, coal tar one of the most valuable and important materials obtained by man. It is not an attractive looking material, and yet there have been evolved from it, by the painstaking labours of a multitude of chemists, substances innumerable dyes by the thousand, which rival in range and beauty of tone the finest products of Nature's imagining; explosives which the strongest works of man are powerless to resist; antiseptics and drugs; the sweet-smelling essences of flowers; and developers of the latent photographic image. This coal tar is, indeed, an almost inexhaustible storehouse of raw materials for the manufacture of products of manifold variety.

By subjecting the crude coal tar to a process of distillation, such as is done in the refining of crude petroleum, various substances are obtained which distil over at different temperatures. Of these the most important are the following:—

LIQUIDS.

		b.p.
Benzine	... ...	176 deg. F.
Toluene	... ...	230 deg. F.

SOLIDS.

		m.p.
Phenol (carbolic acid)	...	106 deg. F.
Naphthalene	... ...	174 deg. F.
Anthracene	... ...	415 deg. F.

Benzine, or, as it is frequently called in commerce, benzol, forms the starting-point in the manufacture of aniline (which can be regarded as benzene in which one of the atoms of hydrogen is replaced by the group NH_2); and this, in turn, is the starting-point in the preparation of a large number of dyes—the aniline dyes. These aniline dyes, which were the first synthetic dyes to be prepared, constitute, however, only a part of the total number of dye-stuffs which are now manufactured from coal-tar products.

Toluene (commercially, toluol) is used as a raw material in the manufacture not only of dyes, but also of the powerful high explosive, trinitrotoluene, or T.N.T.

Phenol, or *Carbolic Acid*, is a well-known antiseptic, and is also the starting-point in the preparation of the explosive picric acid, lyddite or melinite. It is also used in the manufacture of dyes.

Naphthalene is a valuable constituent of coal tar. It is the raw material chiefly employed in the manufacture of indigo.

Anthracene is the raw material employed in the manufacture of a large number of important dyes, the most familiar of which is the red dye, alizarin, or Turkey red.

Important as these different substances are, they constitute only a

small part of coal tar, the amounts in which they occur being, moreover, dependent not only on the nature of the coal used, but also on the temperature at which the coal is distilled. Thus, the benzene and toluene together constitute about 3 per cent., phenol about 1 per cent., naphthalene about 5 per cent., and anthracene about 0.5 per cent. of the coal tar formed in gas manufacture. By the distillation of one ton of coal, therefore, we should obtain the above constituents in the following quantities, roughly :

Benzine and toluene	...	...	lb.	3½
Phenol ...	...	...	..	1¼
Naphthalene	...	...	..	6
Anthracene	...	...	oz	10

Until the middle of last century, men were dependent for all the dyes with which they coloured their bodies or their garments on colouring matters which were chiefly of animal and vegetable origin : the colouring matter of logwood ; the animal dye, cochineal ; the blue dye, indigo or woad, with which our ancestors in Great Britain are said to have stained their bodies ; the red dye, alizarin, obtained from the root of the madder plant once extensively cultivated in Southern Europe ; and the costliest of all dyes, the most famous dye of the ancient world, the Tyrian purple, obtained from a shell fish (murex brandaris) found on the eastern shores of the Mediterranean.

" Who has not heard how Tyrian shells
Enclosed the blue, that dye of dyes
Whereof one drop worked miracles,
And coloured like Astarte's eyes
Raw silk the merchant sells ? "

Browning : Popularity.

These dyes, and a few others, were all that were available until the year 1856. In that year the first synthetic dye, the once favourite mauve, was prepared by the late Sir W. H. Perkin, by the oxidation of crude aniline, and since that time colouring matters to the number of several thousands have been discovered by the chemist. The natural dyes are mostly of a pronounced, even crude colour, but the products of the chemist are of an almost infinite variety ; and, far out-rivalling the natural dyes in range of colour and delicacy of tone, they have ousted these dyes from the dye-works. Starting from benzene, naphthalene and anthracene, constituents of the dirty-looking liquid, coal tar, which less than a hundred years ago was a useless waste material and a nuisance to the gas manufacturer, synthetic dyes to the value of over £20,000,000 are manufactured annually, more than three-quarters of this amount being produced in Germany.

It is quite impossible here to enter into a discussion of the composition and constitution of the coal tar dyes, some of which are among the most complex of the compounds of carbon ; but it may be said that the technique of dye manufacture has become so perfected, and our knowledge of the variation of colour with the constitution of the compound has become so well established, that the synthetic production of new shades is no longer a haphazard process, but one of which the conditions of success are clearly known.

But it is, perhaps, in the artificial production of Nature's own colouring matters, more especially of alizarin and indigo, that organic chemistry has achieved its most striking successes. Through the labours of many chemists the composition of these natural products was determined, and their constitution or molecular structure unravelled, and with the knowledge thus obtained chemists have succeeded in preparing these compounds artificially not merely substitutes for, or imitations of, the natural products, but the actual products themselves and that more cheaply than Nature herself can produce them.

The Madder Plant

Forty or fifty years ago, over the whole of Southern Europe, and eastwards to Asia Minor, great tracts of land were devoted to the growing of the madder plant ; in France alone, 59,000 acres were devoted to its culture. When the roots of this plant were allowed to ferment, a substance alizarin, so called from the name given by the Arabs to the madder root, was formed, which was capable of dyeing cotton of a bright red colour the so-called Turkey red, one of the oldest of dyes, and most largely used in the dyeing of cotton goods. But these madder fields have now all disappeared ; for when the composition and nature of this dye-stuff had once been ascertained, it was not long before chemists discovered a method by which the dye could be manufactured from what was then practically a waste material, anthracene, one of the constituents of coal tar. By a series of comparatively simple reactions, one could pass from the hydrocarbon anthracene ($C_{14}H_{10}$) to anthraquinone ($C_{14}H_8O_2$), and from anthraquinone to dihydroxy-anthraquinone or alizarin ($C_{14}H_6O_2(OH)_2$). In this way the madder dye can be manufactured much more cheaply than Nature can produce it, and instead of the 750 tons of alizarin extracted from madder roots in 1870, over 2,000 tons are now manufactured annually in chemical works.

The fate of the madder threatens also to be the fate of another dye producing plant (isatis tinctoria), from which the much-prized dye stuff, indigo, has for thousands of years been obtained. Even as late as the seventeenth century, the woad was cultivated in Europe, but with the opening up of trade with the East, the European dye could not hold its own with the cheaper indigo obtained from the Indian plantations, and these, until recently, controlled the markets of the world. But even they have not been able to stand against the march of science, and, in the production of synthetic indigo, the conquest of Nature by the chemist and manufacturer constitutes one of the most striking features of the nineteenth century. The fight was a long one, and the writer knows of no other case in which the genius and resourcefulness of the chemist, and the persistence and enterprise of the directors of German chemical industry, themselves expert chemists, have been so conspicuously shown, as in the successful industrial production of this dye. Let us try to recount, in the briefest possible outline, the achievement which has already become historic.

As far back as 1880, the artificial production of indigo was first achieved by the German chemist, Adolf von Baeyer, using as raw material the substance toluene, which, as we have seen, is one of the constituents of coal tar. But although this laboratory production of indigo constituted an achievement of the highest scientific importance, the chemical manufacturer strove in vain to use this discovery in his struggle to oust the natural product. Indigo certainly could be manufactured, and manufactured in quantity, but and this is the whole essence of the matter the artificial indigo cost more than the natural, and the raw material, toluene, was not procurable in sufficient amount to make the displacement of the natural indigo possible. For seventeen years the struggle went on, the chemist assisting with his brains and experience, the manufacturer assisting with his money, until, at last, in October, 1897, after many attempts and many failures, and the

expenditure of close on £1,000,000, synthetic indigo (indigo, that is, prepared by the skill of man from simpler substances) was placed on the market in competition with the natural product from the Indian plantations. And what, to day, is the result of this competition? Hear how eloquently the following figures speak. In 1896 India exported Indigo to the annual value of over £3,500,000; in 1913 her exports of this dye were worth about £60,000, while the German export was valued at about £2,000,000. Moreover, in the above period the price of indigo fell from about 8/- to about 3/6 per lb.

Since the production of indigo involves a considerable number of different processes, and requires the use of a number of different substances, of which sulphuric acid, ammonia, chlorine, and acetic acid are the chief, the success of the synthesis as a whole, depends on the success with which each step of the process can be carried out, and on the cost of the substances employed. The starting point in the manufacture is the hydrocarbon naphthalene, a constituent of the invaluable coal tar, and familiar to all on account of its use in preserving furs against the attack of moths; and the first step in the synthesis of indigo is to convert this naphthalene into a compound called phthalic acid. This, it was known, could be done by heating the naphthalene with strong sulphuric acid; but when the manufacturer attempted to make use of this fact, he found that although the desired conversion did indeed take place, it did not proceed sufficiently readily, and the cost of carrying out this first step in the process was so great that it would have rendered the industrial production of indigo unremunerative. But here a lucky accident came to the assistance of the manufacturer, for, through the accidental breaking of a thermometer, it was discovered that mercury acts as an efficient catalyst in the conversion of naphthalene to phthalic acid, facilitating the process to such a degree as to allow it to be carried out with commercial success.

But the commercial success of the production of indigo depended also on improvements being effected in the manufacture of the various chemicals employed. Thus the demand for a very concentrated sulphuric acid, and the fact that during the process of heating with naphthalene, large quantities of sulphur dioxide are formed, led to the development of a new method of making the acid, namely, by the "contact process." For the production of chlorine, also, of which enormous quantities are required, the old method of obtaining the gas from hydrochloric acid was useless, and a new method had to be introduced, namely, by passing a current of electricity through a solution of common salt, the chlorine being then obtained in a pure state by liquefaction. The ammonia is obtained, as we have seen, as a product of the distillation of coal, and can now also be prepared synthetically; and the acetic acid, of which 3,000 tons are used annually in the manufacture of indigo, is obtained by the distillation of 150,000 cubic yards of wood.

Synthetic Indigo

The industrial production of synthetic indigo, albeit benefiting mankind as a whole, has not only dealt a mortal blow at the prosperity of the Indian plantations, but it has revolutionised two other industries, the manufacture of sulphuric acid, a staple chemical industry of England, and of chlorine, together with that of the bleaching material prepared from it, bleaching powder.

Although it is not possible to enter into a detailed discussion of the practical process of dyeing, it is of interest to note that the process is different in the case of indigo and other so-called vat dyes, from what it is in the case of other dye-stuffs. On account of its insolubility, the indigo is first converted into a colourless compound, called indigo-white, which is soluble in alkalies. After the material to be dyed, which may be cotton, wool, or silk, has been immersed in this solution, it is removed and exposed to the air, whereby the oxygen of the air oxidises the colourless indigo-white to indigo-blue. The dye is therefore developed in the fibre after its removal from the bath.

Closely related, chemically, with indigo, is that other ancient dye, Tyrian purple. Some years ago the nature of this dye was investigated by a German chemist, who extracted it from the glands of two species of marine snails, the Murex brandaris and Murex trunculus, and ascertained that this "dye of dyes, whereof one drop worked miracles," was a compound of indigo with bromine, a compound which can be prepared synthetically with comparative ease. The costliness of this natural dye was almost proverbial, and the reason for this is not far to seek; for the colouring obtained by the German chemist from the glands of 12,000 shell-fish amounted to only about 23 grains, and the estimated cost of the dye was nearly £60 an ounce.

(*To be continued.*)

The Manganese Industry of India

(*Continued from page* 409.)

the regenerative system, fuel charges are reduced to a minimum.

A further advantage is that owing to the gradual heating to which the magnesite bricks are subjected, the proportion of spoiled bricks is very low, and a marketable article of the highest quality and of the top value should be obtained.

It is all a question of getting the right start. The best expert advice should be obtained at the outset, the best and simplest possible plant should be erected at the start, and when once this is set going properly, it is afterwards simply a question of routine in so far as the works practice is concerned, and an organisation of a good sales department on the commercial side. The world itself is a market for high-class magnesite bricks, and if bricks of the right quality are produced, the price is a matter of secondary consideration to the steel maker.

On the lines proposed, there seems no reason why a magnesite industry should not be established with success in India. There are, of course, a number of factors that have not been considered in this article. The question of sites, for example, is one of the greatest importance, but this could best be determined after a study of the local conditions.

Given a suitable site, all the other conditions are in favour of India. Vast supplies of magnesite of exceptional quality, cheap labour, cheap fuel which can readily be adapted for use in the industry, and comparatively low taxation. The main thing to be avoided will be too high a charge for technical supervision and management, but with a properly designed scheme on the lines proposed, these could be reduced to a minimum, and a new industry could be commenced which would offer immediate possibilities to the commercial interests involved, and which would offer increasingly important commercial possibilities as time goes on.

The Magnesite Industry of India

(*Continued from page* 383.)

kiln, in which the heating arrangements are of such a character that a temperature of 1,500-1,650 deg. C. can readily be obtained. In the case of a small plant, this kiln could be used either for the raw material, or for burning the finished bricks. It consists essentially of a long tunnel about 175 to 200 feet long, through which pass steel waggons or bogies fitted with a thick fireclay top. The briquetted raw material or the raw magnesite bricks are placed on these waggons at one end of the tunnel, and as they pass through they gradually become heated, until they reach the firing zone of maximum temperature a little more than midway in the kiln. Heating is done at the start by the waste gases from the products of combustion as they pass through the tunnel on their way to the chimney, until at the firing zone they receive the full heat produced by the special arrangement of burners used.

As they pass out of the hottest zone, the bricks or raw material give up their heat to the incoming air, which is therefore raised to an extremely high temperature prior to its mixing with the incoming air, which is therefore heated to an extremely high temperature prior to its mixing with the producer gas in the burners.

By this arrangement, the bricks or raw material pass out of the kiln in a condition fit to be handled.

The kiln could work on the basis of burning the raw material, say, for fourteen days, and then burn the bricks for a week, etc., or, alternatively, the kiln could be used for burning the bricks during the day shift, and the raw material during the night shift.

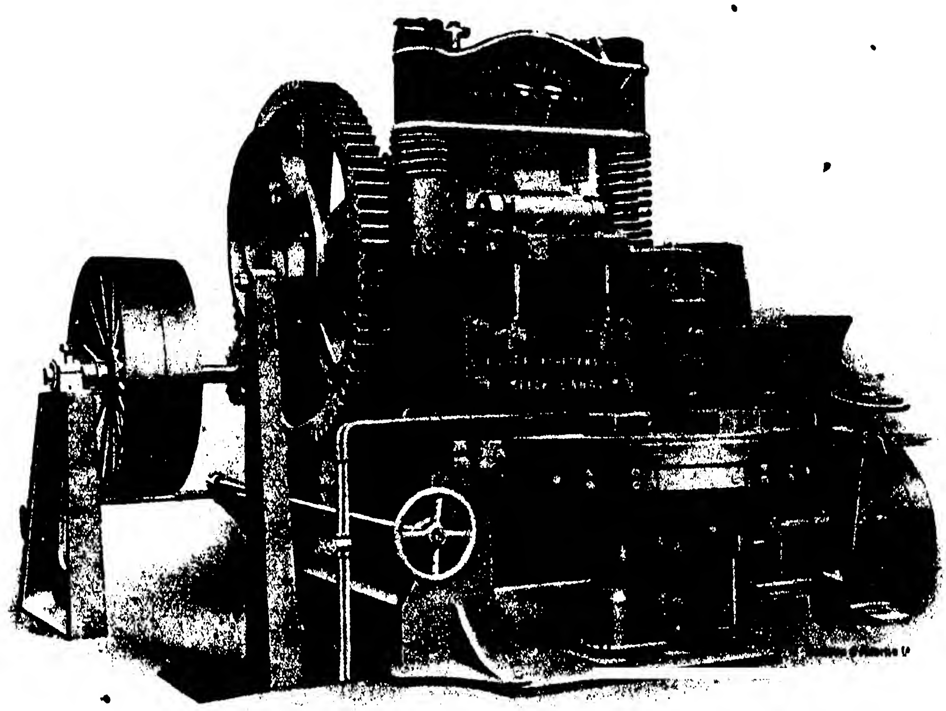
The dead burned magnesite passing from the kiln would pass on to a stone breaker, where it is crushed down to a suitable size; there it is fed by an elevator into an edge runner mill, where it is mixed with a little soft burnt magnesite and sufficient moisture to allow it to be worked into a brick. The mixture is then briquetted at a pressure of two tons per square inch, and stacked on waggons situated in front of the press.

Each waggon takes a load of 400 bricks, and one waggon can be passed into the kiln every hour, so that if the kiln is working only on bricks, an output of 9,600 bricks per 24 hours can readily be obtained.

A kiln of the size proposed allows, therefore, ample capacity for treating the raw material, as well as producing the finished article.

By adopting a system of this kind, working costs can be reduced to a minimum. Labour charges with a plant of the type outlined are extremely low. A tunnel kiln can easily be regulated, and there is no need for the highly skilled labour, and close technical supervision, that is required in the case of a chamber kiln. The heavy items of setting and drawing are reduced very considerably, and owing to the adoption of

(*Continued on page* 408.)



Large Brick Press

INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

Volume II | MARCH, 1923 | Number 8

A Brief Survey of Industrial India

A series of articles, by a well-known Anglo-Indian of long and wide experience, dealing with the history and progress the success and failure of Indian industries during the past twenty to twenty-five years, and an attempt to indicate possible and probable developments in the immediate future. All the figures given are quoted from Official papers and reports.

By Way of Introduction

INDIAN political happenings have loomed so largely in the public eye during recent years, that the industrial and commercial condition of the country has been very little studied, and is rarely clearly understood. Yet few countries possess such infinite opportunities of industrial development. Rich beyond dream in vast stores of potential wealth—with much of it as yet untouched: with industries capable of tremendous expansion—yet with their present output far below what it might be even under the antiquated methods and out-of-date machinery still frequently employed; and with insatiable internal demands—calling for the utmost imagination and tact in their satisfaction; India stands before the Empire and the whole world as a vast storehouse of wealth from which other less bountifully endowed lands may derive an abundant supply of raw materials and commodities for their needs: and as a vast reciprocal market which other manufacturing nations will neglect at their peril. It is no doubt true that the political atmosphere of the past few years has not been conducive to the development of trade and commerce in and with India, but we have, nevertheless, before us a record which may be studied with satisfaction, and one which will imbue wise men with optimism for the future. We have agreed to write this brief survey of industrial India during the past two decades or so, with a view of strengthening this optimism, and to show that India is experiencing at one and the same time an industrial renaissance and revolution.

The Need of a Transformation

Time was when India was almost entirely an agricultural country, but that time, we think, has gone by for ever. The question, which is even now sometimes raised, whether she is to follow mainly agricultural pursuits, or to undergo an industrial transformation, is one that has been definitely answered by the opening up of many huge industrial concerns in all parts of the country. These industrial undertakings are as yet in their infancy, and no one can yet state what they will develop into, or what their ultimate effect will be upon the agricultural pursuits of the people. The unhappy recurrence of famines, the excessive poverty of the masses, the pressure of a rapidly-growing population, all intensify the seriousness of the question of India's economic development. But in an essentially agricultural country, the importance of industrial expansion cannot be overestimated. Dependence solely upon either agriculture or industry in these days creates a dangerous position commercially for any country. It is courting economic disaster to produce raw materials without possessing the necessary means of converting them into finished goods, for, as List tersely puts it, "a nation with a one-sided economic development is like a person with one leg atrophied and only able to limp with the other." In India the need for industrial progress simultaneously with agricultural development, is clear and imperative.

A Lost Industrial Pre-eminence

It is not uncommonly and wrongly supposed that industries and industrial pursuits are new to India. Yet until about the close of the XVIIIth century, India held an important position as a manufacturing country. Her industrial pre-eminence stretches back to the days of the ancient empires of Asia and Europe. Her ships ploughed many oceans, and her colonising zeal has left its impress on names of places and in legends in Java, China, and even in America. Her commerce ranged over all the continents, and the wealth "of Ormuz and of Ind" became proverbial. Imperial Rome decked herself in the splendour of Indian silks and brocades to such an extent that Pliny openly complained of the heavy drain of gold from Rome to India for their purchase. The "wind-woven" muslins of Dacca, the shawls of Kashmir, the brocaded silks of Delhi, early captured the ancient markets of the world. But, alas! the introduction of machinery—and the consequent large-scale production this made possible—proved the death-knell of Indian industries, which languished and perished because they were unsuited to the changing conditions in the economic world, and because those concerned in them were either unable or unwilling to adapt themselves to the changes which were taking place. So, from the close of the XVIIIth century up to quite recent time, India fell behind in the race, and became almost an entirely agricultural country.

The Recurrence of Famines

In this stage of her commercial career, progress has been hampered to an enormous extent by the repeated recurrences of famines. One of the most disastrous famines of the last century occurred in 1896-97, when almost the whole country was overwhelmed, and an appalling holocaust of victims occurred. Want of water and fodder also caused an appalling destruction of agricultural cattle. Before the calamitous effects of this famine could be effaced, the country in 1900-01 was swept by a similar disaster, which called for an expenditure of 10.68 crores of rupees in relief and over 4.11 crores of rupees in loans. The agriculturists who had survived the calamity of 1896 were so woefully crippled when the second calamity overtook them, that they had practically no resistance left, their cattle had all perished, and for over ten years they suffered from the effects. It is estimated that the agricultural loss in 1900 alone was 225 crores of rupees.

India's Agricultural Progress

A survey of agricultural progress since those years of disaster may be of help and interest. In 1901 the total area actually under crops was 21.02 crore acres, of which 17.70 were food grain crops. In 1908-09 the figures were 23.65 crore acres, of which 19.68 were food grain crops. These figures show an increase in the area of food grains of 1.98 crores, equivalent to 11.2 per cent.; while the increase in the area of mercantile crops was equivalent to 19.6 per cent. Since then the extension of irrigation by canals and reservoirs, the improvement of modes of cultivation, the reclamation of waste land into tillage, the use of scientific manures, and other improvements, have considerably reduced the ravages of famine, and also enriched the output of raw materials for manufacture. In point of climate and fertility, land in India yields to none in the world, and enterprise alone is needed to develop its agricultural resources. Out of 621 million acres of land in British India, only two-thirds is to-day under cultivation. Out of a total of 388,375,000 acres available for cultivation, *i.e.*, 63 per cent. of the total acreage in British India, the aggregate amount under tillage is 222,825,000 acres, or 36 per cent. of the total area. Of the remaining 27 per cent. that could be cultivated, 18 per cent. has not even been taken up, while 9 per cent. is intentionally kept fallow. Government officials state that if the whole available acreage were put under cultivation, famine would be reduced by over one-half, and probably even more so if new methods of cultivation were introduced, for the present yield per acre, as pointed out in the last issue of INDUSTRIAL INDIA, compares most unfavourably with that of other parts of the world. It may be broadly stated that while progress has undoubtedly been made with agriculture during the last twenty years, very much more might have been done. Not only is much potential wealth going to waste in the untilled lands of this great country, but even the land under cultivation is worked in anything but a scientific and efficient manner, and consequently far below its full producing power. Fields are only ploughed very shallow, and are either badly manured, or else not manured at all. Irrigation, in many districts, even to day, is totally neglected, or else carried out in such an imperfect and inefficient manner as to be of little use. Even when seed is purchased, it is generally of such an inferior quality that its productive force is very small. It is estimated that if the intensive methods of cultivation which prevail in Japan and in Holland were employed in India, agricultural production could be increased by at least fifty per cent.

The Co-operative Movement

Improved methods of agriculture can, however, only be popularised when the mind of the worker has been educated to appreciate and value them. The Indian peasant is the victim of inherited qualities and conservatism strengthened by custom which are antagonistic to change. He views with suspicion and repugnance any departure from time-honoured methods or the introduction of any new implement. Improved cultivation, the use of scientific manures, the employment of irrigation, have no fascination for him. He plods along in the manner of his forefathers, takes no thought for to-morrow, and expresses little, if any, interest in the advance and progress of other nations. At the same time, signs are not wanting that an awakening *is* taking place. One of these signs is the continued and unchecked growth of the Co-operative Movement throughout India. Not only from the point of view of reducing debt a very heavy burden upon most Indian agriculturists and placing the agriculturist upon his feet: but also from the point of view of its beneficial effects upon the character and habits of the people, co-operation is full of promise for the future. The Co-operative Movement in India will be dealt with in a later article. Suffice it here to quote the following extract from the official "Statement of Progress in India," published last year: "*The steady and solid growth of the co-operative movement is by degrees providing the necessary foundation for a corresponding progress in scientific agriculture. The means of the Indian cultivator are very limited, and in most cases do not permit of outlay either upon improved agricultural implements, or upon expensive fertilisers necessary for supplementing soil deficiencies. The Indian cultivator needs improved seed, improved tools, and improved methods; and unless these can be placed at his disposal, he cannot be expected to achieve much progress. The help which the co-operative system can afford in overcoming these difficulties is undoubted, and the prospect of future prosperity which it opens up to the peasant is most encouraging. At present, since his means are small, the Indian agriculturist often fears to take up new methods until he is convinced beyond all possibility of doubt that he is going to do much better without a large extra expenditure of labour, and of money. The world's progress is affecting agriculture equally with other occupations, and unless the agriculturist can be equipped with the knowledge, as well as the capital, for developing the resources at his disposal, it is difficult to see how he will in future support his share of the economic burden from which no nation on the road to self-government can escape.*"

There can be little doubt that with the spread of the co-operative movement, the problem of agricultural indebtedness which is one of the most serious problems confronting the agriculturist to-day, with its attendant evil and depressing effects will, in the course of the next few years, have lost much of its terrors. Perhaps even more important, from the point of view of the general progress of India, are the moral effects of co-operation and, in this connection, both litigation and extravagance are diminishing. In the Punjab, for example, many co-operative societies have passed rules prohibiting certain forms of ceremonial extravagance. Co-operation is slowly but surely creating what India so greatly needs, viz., a public spirit, and a sense of common citizenship which will be of

(*Continued on page 432.*)

THIS MONTH WE ARE FEATURING A SERIES OF SPECIAL ARTICLES RELATING TO RECENT MINING DEVELOPMENTS

Utilisation of Waste Fuel in Colliery Boiler Houses

By E. C. REED

VARIOUS estimates have been made by eminent scientists from time to time as to the probable date when the coal supply of this country will be exhausted. These range from 120 to 500 years, but Sir William Ramsey once made the definite statement that in 150 years the price of coal would be so great that a large portion of our industries would have to be shut down. He attributed this to the undoubted fact that the need for coal would become greater and greater as time went on, so that there would be, on the one hand, a constantly increasing demand, and, on the other hand, a constantly decreasing supply. The premises are doubtless correct, but, with all respect, the conclusion is invalid, because it is based on the unscientific methods then prevailing, and fails to take into account several factors, of which the chief are: the availability for certain purposes of other sources of power, the great and growing improvement in methods of combustion, and the development of mechanical stokers and self-clinkering furnaces to deal with classes of coal hitherto regarded as useless for steam raising purposes.

Colliery Practice

From the point of power production, the colliery manager is in the unique position that it is at his disposal at a cost considerably less than at that of any of his professional brethren engaged in any other industry. And if he concentrates his attention upon this important branch of his calling, he will find that once he has procured suitable plant, and established the necessary organisation to work it, the power question cannot only be solved at practically no expense for fuel, but that his own time expenditure for supervision will be very trifling.

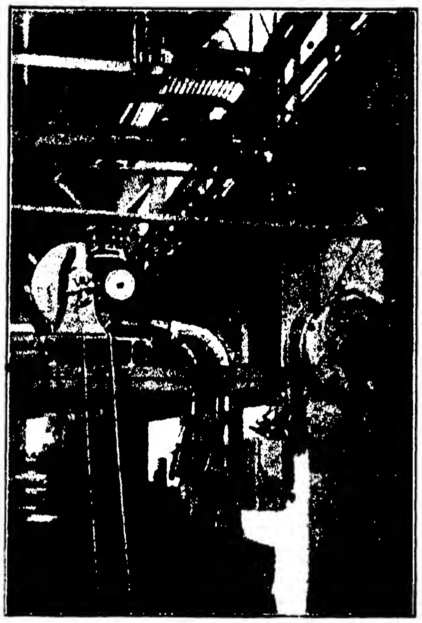
Of the coal used in Great Britain, 90,000,000 tons per annum, or 18 per cent. of the total, is used for steam raising, of which a very considerable proportion is used for this purpose in the collieries themselves. It is by no means unusual to find that the fuel consumption in a colliery reaches to as much as ten or more per cent. of the output, and, though some of it is good quality marketable coal, much of it consists of pit sweepings, with, generally, a high ash content.

It is this fact which has been largely responsible for the inefficiency which has in the past been a characteristic of colliery boiler houses. The Control Board, in 1916, calculated that the average total efficiency of boiler plants in this country was then about 65 per cent., but this average, low as it is, is but rarely reached in collieries. When it is remembered that in modern boiler house practice, an efficiency of from 75 to 80 per cent. is fully practicable, the need for improvement is obvious, and this need is more apparent in collieries than elsewhere, owing to the fact that such a low general average is reached simply because the boiler efficiency in collieries rarely rises to 65 per cent., and is, in many cases, as low as 45 per cent. It will be seen, therefore, that a colliery having an efficiency of the latter figure can, by the installation of suitable plant and organisation, have its efficiency very considerably increased.

Low Grade Fuels

That colliery owners and their engineers have not been slow to profit by the experience gained in recent years is proved by the large number of new boiler house plants laid down in various collieries throughout the country, these plants invariably including means for utilising as fuel much material of a low grade and largely unsaleable nature. Among the first of such appliances we must put mechanical stokers, which in recent years have made great strides in the direction of burning waste fuels satisfactorily.

In colliery practice, the great advantage of mechanical stokers is the ease with which they can burn low quality coals successfully. In hand-firing, an excellent stoker none too plentiful working with a sense of responsibility and a knowledge of the principles of combustion, can, by exercising care and skill, produce very good results from high-class coals, but it is obviously a most wasteful procedure to use up high-priced, good quality coal in a boiler furnace, when a mechanical stoker can produce the same, or better, results from coal that is, in the ordinary way, unmarketable, such as pit sweepings, belt-pickings, washery refuse, and even pond settlings. Under modern combustion conditions, there is no reason why the huge piles of fuel which now disfigure the colliery districts should not entirely disappear from our countryside, and by being used in the boiler furnace, release the better coals for a more worthy purpose. It is but natural that colliery managements, who are the losers when worthless matter is laboriously got from the bowels of the earth, should, if after all it is found that such substance has some combustion value, however small, be the first to benefit by this. And they can now do so by selling the coal of marketable value hitherto burned by hand-firing under their own boilers, and



Turbo-Pulveriser at a Durham Colliery using Low Grade Coal — *Powdered Fuel Plant Co.*

substituting these low-grade fuels for the production of the power needed by the collieries themselves.

A typical example is that of a colliery in Durham. In the case referred to, a large quantity of cannel coal, belt-pickings, pond settlings, etc., being available, the Company took into consideration the possibility of mechanical stokers, and so releasing the good quality slack then being used in hand-firing the boilers for use in other directions.

Plant under Test

The steam plant consists of six Lancashire boilers, each 30 ft. by 8 ft., with pressure at 100 lb. per square inch, the feed-water temperature being about 160 deg. F.

The stokers are designed to raise steam from all sorts of refuse fuel, and tests were made on the plant with the object of determining the power of the stokers to utilise at the colliery the lowest grade fuels produced, which had been looked upon as practically mere refuse. At that period (as, indeed, still is the case), it was a matter of the highest importance to leave the whole of the better fuel available for use elsewhere, and to make use of the unsaleable residue for the production of the power needed by the colliery itself.

Three classes of fuel were used on these tests: the "cannel coal," a fuel in large lumps, with a great deal of shale irregularly distributed in the mass; belt pickings, or the portion thrown away by the pickers as quite useless; and the washery refuse. This latter proved to be nearly quite incombustible when fired by itself, but the difficulty was overcome by mixing it with a proportion of the "cannel coal."

Test Results

All the tests were made on a Lancashire boiler, 8 ft. by 30 ft., of 1,000 square feet heating surface, fitted with a "Bennis" hand-fired furnace of 41 square feet.

Test yielded the following figures:

Class of fuel burnt.	Cannel coal.	Belt pickings.	Cannel coal mixed with washery refuse.
Fuel burnt per hour ... ... lbs.	1,204	1,269	1,045
Fuel burnt per sq. ft. grate per hour	29.4	30.9	25.5
Percentage of ash and clinker	18.6	66.2	
Water evaporated as from and at 212 deg. F. per lb. of fuel ... ... lbs.	5.28	3.65	5.03
Water evaporation as from and at 212 deg. F. per hour ... ... lbs.	6,365	4,632	5,260
Average temperature of feed water entering boiler ... ... deg. F.	150	167	160
Average steam pressure by gauge — lbs. per sq. in.	66	73	72

With these fuels it was found possible to produce from 4,600 to 6,300 lb. of steam per hour from the boiler, thus not only avoiding the consumption of better-class material, but making profitable use of what had been only an encumbrance.

South Wales Conditions

The case of South Wales is of peculiar interest, because for many years prior to the war, the South Wales area was largely a barren field so far as mechanical stokers were concerned. This cannot be regarded as due to any lack of enterprise on the part of the colliery managements, but is to be explained by the complexity of the circumstances, and was justified until the mystery was solved. There were, of course, the conditions, common to all colliery districts at that time. Abundant supplies at low cost encouraged waste and extravagance, so that economy practised on any sort of scientific system came to be regarded as a sort of work of supererogation, incompatible with high efficiency; a counsel of perfection to which few dared aspire, and one, moreover, which brought no reward save that of self-gratification. It was difficult enough in those days for a stoker manufacturer to show a saving at all at a colliery, while to persuade anybody of its necessity was a veritable labour of Hercules.

Added to these conditions, there existed, in South Wales, circumstances peculiar to that district which made the claims of the stoker manufacturer very difficult, and often impossible to substantiate in practice. The chief of these lay in the varying quality of the coals. As is well known, South Wales coals differ very considerably in their chemical and burning properties, and this often led to the apparent anomaly of a mechanical stoker performing its function successfully at one colliery,

and less satisfactorily at another one a stone's throw away. Not only that, but cases were not unknown in which at the same colliery a mechanical stoker worked admirably for a few days, and then failed to maintain the results. The difference was not so much due to the stoker itself as to the fact that the coal supplied to it at one period gave different results in combustion from that supplied at another. In ordinary industrial works the mechanical stoker was installed to meet certain conditions, and in most cases the coal was of known calorific value, and the quality remained at a comparatively uniform standard over long periods of time. The war, however, made it necessary for everybody to use whatever coal the gods, in the shape of the Control Board, cared to send. The better quality coals disappeared alike from the domestic hearth and from all ordinary industries of the country. This circumstance had its effect upon the design of mechanical stokers, and led, among other things, to the construction of mechanical stokers specially designed to meet the new conditions.

The essential difficulty of dealing with South Wales coals on mechanical stokers arose from the fact that the stoker had only one speed of working. As is well known, the speed of movement of the grate relative to the timing in feeding the furnace with fuel, has a most marked effect upon the efficiency of the furnace, the cleaning of the grate, and the furnace temperature. In the new stokers provision is made for an independent range of adjustments for the speed of the grate, and the rate at which the fuel is fed to it, so that they can be regulated independently one of the other. The result is that though this machine may be burning one particular grade of coal to-day, it will burn a different class of coal, with equal efficiency, to-morrow.

These stokers have been installed in several of the largest collieries in South Wales, and sufficient length of time has now elapsed to be assured of their successful performances.

Boiler Efficiencies in Collieries

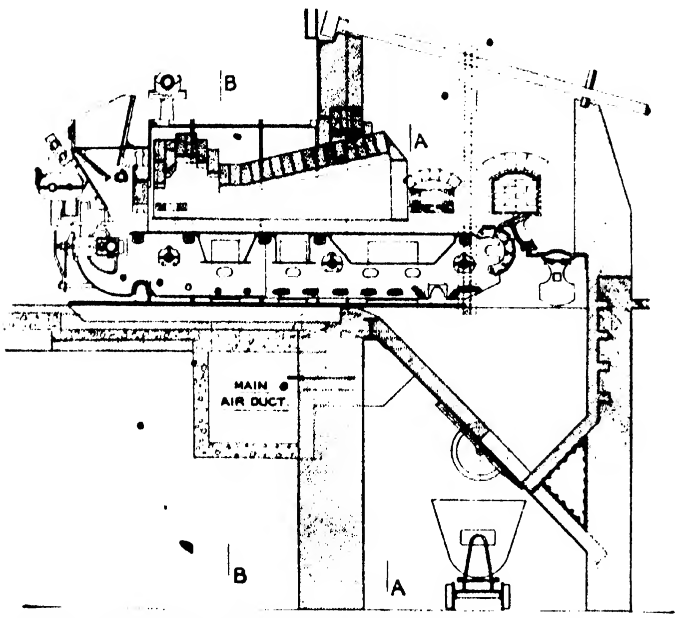
It would appear from tests taken that the colliery industry has the lowest boiler efficiency of any in the country, the average for 100 boilers inspected being only 55.5 per cent. What can be done is shown by the table of tests above, which shows the average of twelve recently-conducted tests on hand-fired boilers at collieries, and a similar average of thirteen tests on Lancashire boilers at collieries fitted with sprinkler stokers and compressed air furnaces.

It is only fair to say that in the matter of coal, collieries have certain difficulties of their own, and much of the wastage is, under present conditions, unavoidable. It is difficult to get good stokers for hand firing at collieries, or, for that matter, anywhere else. Indeed, one of the chief factors in the invention and development of mechanical stoking methods is the increasing reluctance of men to undertake this dirty, disagreeable, laborious, and often disappointing work, whilst the necessity for using up low-grade fuels, the consecutive shifts, and the intermittent demand for steam are other difficulties of colliery practice. With the new type of stoker, however, all these difficulties

COMPARISON OF TESTS ON COLLIERY PLANTS

		Hand fired	Mechanically fired
Number of plants tested		12	13
Boiler hours		179	149.83
Average boiler hours per test		14.92	11.52
Calorific value of coal used (average)	B.Th.U.	12,699	12,247
Percentage ash in do. (average)	per cent.	12.3	15.14
Total coal used	lbs	218,743	216,728
Coal burnt per boiler per hour	lbs	1,222	1,446
Coal burnt per boiler per sq. ft. grate area per hour	lbs	29.9	35.52
Draught at chimney	ins W.G.	0.92	0.77
Draught at leaving boiler	ins W.G.	0.632	0.49
Temperature flue gases leaving boiler	deg. F.	681	772
Percentage CO_2 in flue gases	per cent	9.4	12.47
Total water evaporated (actual)	lbs.	1,284,796	1,541,900
Average steam pressure	lbs. per sq. in	116	116
Average feed temperature into economiser	deg. F.	90	90
Average feed temperature into boiler	deg. F.	210	210
Superheat above saturation temperature	deg. F	124	157
Factor of evaporation		1.23833	1.25705
Total water evaporation from and at 212 deg. F.	lbs.	1,591,000	1,938,245
Water evaporation per boiler per hour (actual)	lbs.	7,178	10,290
Water evaporation per boiler from and at 212 deg. F.	lbs	8,888	12,936
Water evaporation per lb. of coal (actual)	lbs.	5.873	7.114
Water evaporation per lb. from and at 212 deg. F.	lbs	7.273	8.943
Water evaporation per sq. ft. heating surface per hour from and at 212 deg. F.	lbs.	7.41	10.4
Total thermal efficiency	per cent	55.54	70.81
Thermal efficiency, boiler only	per cent.	46.83	58.81
Thermal efficiency economiser	per cent.	5.56	6.98
Thermal efficiency superheater	per cent	3.15	5.02

Bennis Stoker designed for Refuse Fuel



Babcock & Wilcox Stoker for using Waste Colliery Fuel

are fully met, so that collieries are now enabled to produce all the steam they require from fuels which have otherwise practically no value at all; the human element, with its uncertainty, its unreliability, and its temperamental repugnance to the arduous and largely thankless task of firing by hand, is reduced to its proper place of supervision and control of the machines; the stoker will give ready response to any demands for steam, however fluctuating, and after allowing for the capital outlay and the cost of wear and tear, the stoker will effect a considerable saving, and continue to save year after year.

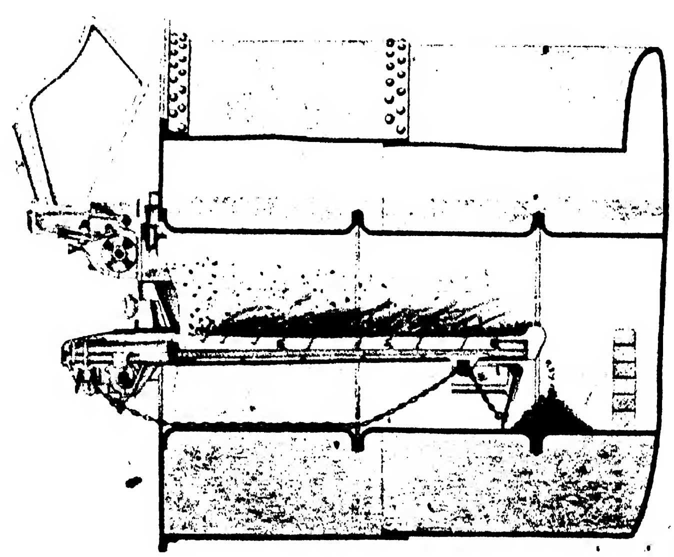
Stoppage of Plant

There is, finally, one advantage of mechanical stokers which should appeal with particular force to colliery owners and engineers, namely, that in the event of a strike or other emergency involving a stoppage of work, serious losses, and possibly danger, are likely to occur in the mines if the steam is entirely shut off. With mechanical stokers, if the regular firemen fail, the boilers can be worked by unskilled labour, not perhaps with the same degree of success, but sufficiently well to maintain the steam required for such important operations as pumping, ventilation, etc. There were many instances of this during the recent coal strike. In one case, all the boilers were of the same type, but some were hand-fired, and the others mechanically fired. It was regarded as impossible to obtain labour of the type required to stoke continuously the hand-fired furnaces, and they were allowed to go out, the situation being saved by working the mechanical grates with amateur labour. Sufficient steam was thus kept up during the whole period to continue all the most vital operations.

Powdered Fuel

This section would be incomplete without some reference to the use of pulverised, or, as it is generally termed, "powdered" fuel. Coal in this form was first successfully applied to cement burning kilns, and is largely used in this industry, though it was in form very coarse compared with the fineness now obtained, whilst the ash, which has always been a fruitful source of trouble in other attempted applications, is in this process a useful addition to the ultimate produce.

Of recent years powdered fuel has been applied with some success to steam raising both at collieries and elsewhere. This development, however, is more noticeable in America than in this country. The process, as first introduced, was very costly, and showed no great advantage in actual operation, whilst the liability to spontaneous combustion, and the greater risk of explosion, made commercial progress difficult. At the same time, the possibility of this system must not be ignored. It is not yet perhaps fully developed, but many difficulties have already been overcome, and there is no reason to doubt that the use of powdered fuel, which has many advantages to recommend it, will make considerable headway. The few installations already in existence in this country prove that, if not yet fulfilling all their first promises, the proposition is commercially practical, and, in an increasing degree, commercially profitable, especially in collieries where a large untapped reservoir of small inferior coal is available.



Section through Bennis Stoker for Low Grade Fuel

Electricity Applied to Mines

The following instructive notes are taken from the replies of Mr. John Bentham to the discussion on his paper, read before the Yorkshire Branch of the National Association of Colliery Managers

MR. BENTHAM said that Mr. Ball had sent him a question with reference to the size of switches, from 200 amperes up to 2,000. In his paper he was really dealing with high-tension rather than a medium-pressure supply. On the main board in the power house it was better to standardise all the cubicle units if possible, and generally 150 to 200-ampere sizes were quite suitable, although, of course, conditions might occur that would require standardisation of larger-sized units. But in the case of a medium-pressure supply at, say 500 volts, and dealing with currents up to 2,000 amperes, the only thing possible, if one desired to keep one universal cubicle spare, would be to take the largest size and change the series overload coils in the switch to suit the circuit that one desired to put this switch on. This was not a serious proposition, and having a few spare overload coils in stock was less expensive than switches—that is, spare switches for every main cubicle circuit.

As to the lowering the cable down the shaft with the drum on the top deck of the cage, that was quite a good idea, but everybody was not so fortunately situated as Mr. Ball in this respect. Naturally they would find narrower shafts and narrower cages, and in these cases the best way was to lower the cable by means of a rope. Of course, where the drum could be fixed on the top deck of the cage, and they could start away from the top and cleat the cable as they went down, this seemed a very good proposition, and he should say it was a very good method of installing. At the same time, they must bear in mind that when they started lowering the cable by that means they had to continue through the whole shaft and get the cable into position, and that might prove detrimental if they needed the shaft for any particular purpose in a great hurry. Therefore the reason why he always recommended lowering cables by means of a rope was that they could release the shaft at any time for any particular or urgent call. Then, again, the question of taking the cleats into the cage to go through the whole shaft, and being able to get any special tool that might be required, had to be taken into consideration.

Cleats

With reference to the cleats, they generally made theirs for, say, a 2 in. cable, 4 ft. long, 8 in. wide, each half about 3¼ in. thick, 2 in. thickness of wood between the bottom of the groove where the cable rested in and the face of the cleat. In making the cleat they generally bolted the two halves together with a spacing piece in between the two faces ¼ in. thick, and bored out the cleat to the true diameter of the cable; this gave a nice friction grip, and taking into consideration that a cable was covered with a great deal of covering over, and generally between the rings of armour, the ¼ in. friction grip did not damage the armour of the cable or otherwise crush the enclosed conductors. In the old days he had known cases where cleats had been made 1 ft. long (two halves, each 6 in. thick), allowing a cable grip of ¾ in., and when this cable was put into commission they were very lucky if they were free from a short-circuit between one of the lines and armour.

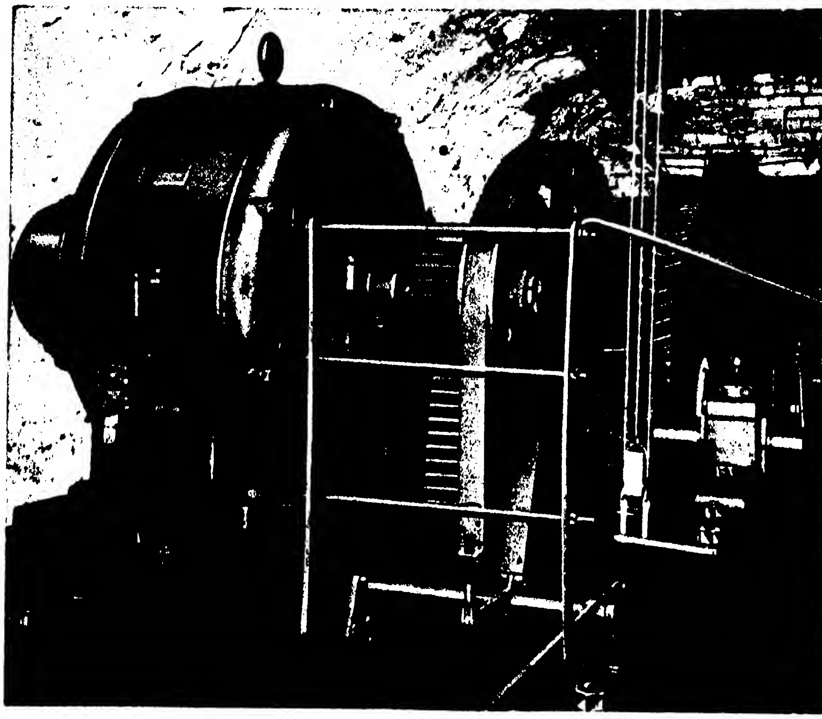
Mr. Ball had asked whether it was not better, from the point of view both of efficiency and maintenance of the power factor, to instal motors as near the work as possible, rather than to have a large reserve of power. In the modern design of motors a good power factor was obtained on motors at three-quarters load, so taking any motor working from three-quarters load up to the specified and time-overload conditions gave a fair amount of flexibility and generally met most conditions, but in special conditions, where it was desired to put in a large motor allowing for future extensions, the power factor could always be improved by apparatus attached to the motor. In cases where a number of these motors were being installed, a great deal larger than at present necessary, with a view to future extensions, the power factor of the whole system could be brought up by means of the synchronous motor or condenser, but from his point of view the condenser was a much better proposition than the synchronous motor. It had the advantage that it could be installed in units to bring up the power factor of the system as required, and of course this method should only be resorted to when it was not possible to instal a motor or motors working at not less than three-quarters load.

Mr. McTrusty had asked what was the cost of increasing the power factor from 0.85 to 0.95. This depended on the k.v.a. Assuming it was desired to raise the power factor of 87 k.v.a. from 0.55 to 0.95 on a 500-volt 3-phase supply, this would require a condenser having an output of 57 k.v.a., which would cost about £250. In some cases, to bring up the power factor on a 750-kw. plant from about 0.6 to 0.95 might cost between £2,000 and £3,000, complete with all gear. Cases had occurred where the installation of these condensers had effected a saving of £400 per year where power had to be bought.

Suspenders

In replying to Mr. Gill's question with regard to round iron suspenders and flat-iron strip suspenders, he (Mr. Bentham) had used both types, and preferred the round ones. If they used flat strips the corners ought to be rounded off by means of a file before the cable was suspended from them. He had found the round ones rather easier to make, and he thought round ones were more used than the flat-strip type. In any case, this was a matter of small moment. Either of the two types was quite all right. He always used flat strips bolted to the overhead suspension wire to support any overhead armoured cable, and round and flat down the mine, where and when required.

In reference to lighting and armoured cables, he did not at any time care for piping, and if armoured cables were treated with Stockholm tar they should stand up to their work as easily as metal tubes. The trouble



Electric Motor Driving Endless Haulage Gear *Metropolitan-Vickers Electrical Co. Ltd.*

with piping was bad and rusty joints, and sometimes condensation. He had withdrawn cables from a piping system that had only been in a few months in a wet place, and all the cables were found to be wet and slimy. This had also been found to be the case where cables had been installed in pipes in stables on the surface and underground. This system had been replaced with armoured cables, and everything was O.K. Armoured cables were just iron, in the same sense as an iron pipe, and he could not see why they should get more corrosion in using iron armour than an iron pipe, and so he should be prepared to put in armoured cables in all cases. Such cables were used in shafts, and in some cases they were working under very bad conditions, and where piping could not be used. If they could not use piping in a shaft, and were bound to use armoured cables, he did not see why they should want to use piping in preference to armoured cables. He had cables working under very bad conditions, and was prepared to back armoured cables every time against ordinary cables in any kind of tube.

Cleats

His remarks to Mr. Ball on the subject of cleats would more or less answer Mr. Gill's questions, with the exception of the grip he allowed on the cable. Just a saw cut was rather fine. He was prepared to err on the side of safety, and considered ¼-in. grip not too much. Even a ⅜-in. grip on a decent cable would do no harm, but above that he would not be prepared to go. He thought that a ¼-in. friction grip on a 4 ft. cleat made a nice neat job. In reference to the distance apart, irrespective of the weight of the cable they always put in their cleats from about 20 to 25 yards apart. It was better to err on the side of safety, although it might be a light cable, than to increase the distance apart between the cleats. It was not wise to let a cable hang down the shaft unsupported for a distance of 50 or 60 yards, as this really meant that the conductors were to some extent depending upon the insulation for support. This had been proved at various times by the broken conductors in a small shaft cable. To eliminate this, cleats should be put in at less than 25 yards apart.

Replying to Mr. McTrusty's question as to lowering the cable and tying on every 6 or 7 ft., he thought this was modern practice. As to instantaneous time elements, he would stand by his first statement. A short time ago he completed 21 years' service as chief electrical engineer to a colliery company, and during that time he was responsible for the whole of the erection of the power and lighting plant. In 1901 he put down a 100-h.p. motor, and in 1904 another 100-h.p. motor with instantaneous elements. These motors had been running from that time up to the time he last saw them without a halfpenny being spent on them for repairs other than the usual cleaning and renewal of brushes. That was a fairly good record, and, judging from his experience, he did not think there was anything really to warrant time-lag elements on motors other than series-wound coal-cutter motors and squirrel cage motors, in the latter in the starting position only.

Where motors were installed with time-lag elements they would generally find that, if any internal shorting happened, the motors suffered more damage than if instantaneous elements had been employed. He always found that setting the instantaneous elements to the normal overload of the motor offered ample protection to the motor. Moreover, if anything should happen on the haulage road, such as a tub getting off the rails and bumping into a prop, the motor, instead of receiving some considerable damage, which was possible if held in circuit by means of the time-lag element, would immediately reach the overload value and trip out. At the same time, instantaneous elements helped to protect motors in this way; faulty starters had to be eliminated more so than in the case of the time-lag.

When he was referring to the squirrel-cage motor, and having time-lag elements on the starting position, he really meant that when they started up the motor and got a sudden rush of current in the starting position momentarily, it was advisable to have time-lag elements in the starting position only, and then, when they changed over to the running position, they could have their motor protected by means of the instantaneous element. That was better than having time-lag elements only. But in some cases, as he had mentioned before, for coal-cutting with series-wound motors on D.C., as soon as they switched on it reached the instantaneous value with overload at once and tripped out. In this case time-lag elements had to be employed. Of course, the working conditions of a mine varied, and where motors could not be run without a time-lag

element he would at no time set the time element to more than two seconds. The reason why he advised the instantaneous value elements was that on the switches protecting the motors it was no common thing to see the trips set to 50 per cent. overload, with a time-lag of seven seconds —actually no working protection to the motors.

Cable Standardising

In reference to Mr. McTrusty's remarks about standardising lengths of cable, he might say that in the early days he even went one better than that. They had standardised their cables to 100-yard lengths, and had link-disconnecting boxes every 200 yards, and in some every 100 yards. Of course, there was a diversity of opinion, and it was not always wise to recommend that system to colliery managers. The managers generally said: "We do not want to cut this cable into smaller lengths than possible and then have to insert junction boxes." In cases of this kind they had to be governed by conditions. Some collieries could deal with longer lengths of cable than others, and if they could they saved the cost of a joint box at various points along the route. A junction box on a cable should really be put in a recess in the wall and mounted on a brick pillar, the box bolted down to the pillar and the cables anchored either side, but this was, of course, expensive. If cables were installed in long lengths, say 300 to 400 yards, some of the expense of building brick pillars and making recesses was eliminated, and many managers preferred that to installing a standard cable 100 yards long and putting in a joint box every 100 yards.

He agreed with Mr. McTrusty that when a fault occurred on a cable it was nice to think that they had got one standard length of cable, say 100 yards, which they could sectionalise and find out where the trouble was. Of course, these boxes were link-disconnecting. If they were not, and the straight-through type were employed and filled up with compound, standardising cables to any length had nothing to recommend it. When standard length of cables were employed in conjunction with link-disconnecting boxes and the faulty section had been found, a new standard length of cable could be put into commission from one box to the other and the faulty section brought out of the pit. Many managers did not care to go to that expense. If not, the only thing to do was to take in the longest length they possibly could with safety, then to join the cables together by means of suitable joint boxes filled with compound, mounted, bolted, and anchored to a brick pillar in a recess at the road side. The cable should also be anchored to the brick pillar by suitable iron clamps. Then, should there be a fall of roof or anything of that kind, they were not likely to get such a severe strain on the armour glands of the box. He had known cases where falls of roof had dragged the connections out of the box, torn the box from the pillar to which it was not bolted down, dropped it on the floor and broken it open. So it was really better to anchor the cable at either side of the box to the brick pillar with metal clamps, and to the props at either side. If not, and the box was only put on a pillar, or on a ledge at the road side without any metal anchors, they risked the box being brought down with a fall of roof and broken open, and this might cause open sparking.

As to transformers buckling, he had experience of this apparatus for a number of years, but had never been so unfortunate as to meet a transformer the walls of which would not bear its own weight, or which would buckle. All the transformers that he knew were strong and robust enough to be wheeled anywhere. When he considered that he had transformers at different places weighing three, four or five tons, to deal with that did not buckle, he should hardly apprehend any buckling from a small transformer such as was generally used in-bye in a coal mine. If they did get buckling, he should be inclined to fall out with the people who made the transformer, and to tell them that they really did not know their work, and that the design was at fault.

Leakages

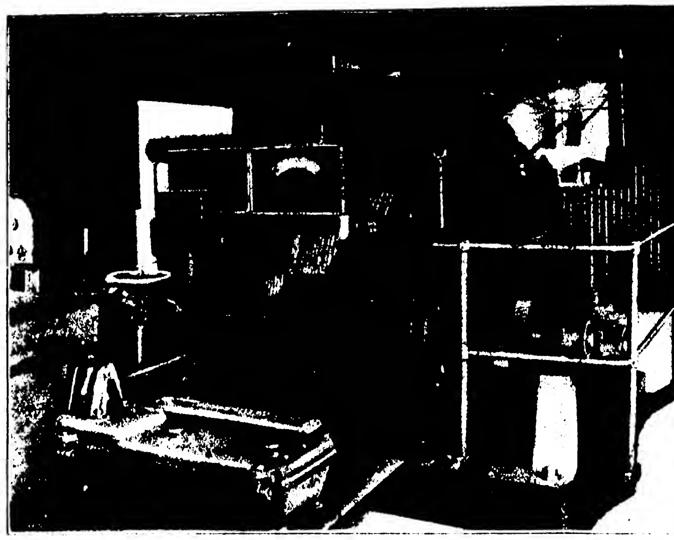
In reference to leakage protection and indicators, they could have leakage indicators and leakage trips. One could have a leakage indicator showing the state of the insulation of the system in conjunction with leakage trips. But he felt sure that H.M. Inspectors did not press them to have leakage indicators of the visible type in conjunction with leakage protection, because really leakage protection was very much better than visible leakage indication, and the leakage protection as they knew it was leakage indication which automatically opened out the circuit when a fault occurred, and with the higher pressures it took very little leakage current to open the circuit. The visible leakage indicator was quite useful where an unearthed neutral was employed, and although an indicator

Winding Engine driven by D.C. Motor *Metropolitan-Vickers Electrical Co. Ltd.*

was used, the danger was that a leakage might be neglected until one of the other lines went to earth before the overload trips came into operation. It was better to have automatic small leakage cut off protection at all points if possible. If a visible leakage indication was necessary at one place, it would also be necessary at every point where a step up or down was made, and instruments for this purpose underground would often be neglected, so it was very much better to have the leakage protective device, which was in itself a leakage indicator that automatically opened out the faulty circuit or circuits, and could not be neglected like the ordinary type of visible indicating leakage instrument. Leakage protection could also be set to certain values which worked very well on the lower pressures, but on the higher pressure circuits a small fault on an armoured cable with an earthed neutral was a large one in a very short time. And generally a limiting resistance was employed between the neutral and earth.

Mr. McTrusty, emphasising his question as to the instantaneous cut out, said the point was that if they got a motor running at 20 amperes, and it was set so that it would trip out instantaneously at 20 amperes, which was the working load, the thing would be too delicate, but if it was set to the overload condition of the motor it met his point.

Mr. Bentham: That is right; that is what I mean. I have been doing that for years. Dealing with Mr. Waterhouse's questions, Mr. Bentham went on to say that to give the relative merits of A.C. and D.C. would require a paper in itself. Speaking about the merits of A.C. and D.C. as mentioned in his paper, one thing to recommend A.C. was when a large field had to be covered and large powers transmitted. If it was desired to use D.C. down a mine and transmission of large horse-powers was necessary, the size and cost of cables would make it prohibitive. He had a case in point where 0.6, 0.5 and 0.15 at 440 volts D.C. were used, and the power transmitted by these cables was very small. If they took a three-core cable, each conductor 0.1 sq. in., the pressure employed 3,300 volts, and 0.8 power factor, and assuming 1,000 amperes per sq. in. and the same section of copper used on the D.C. system, the horse-power transmitted on the D.C. system would bear no comparison at 440 volts with the horse-power transmitted on the A.C. system at 3,300 volts.



90 h.p. Slip Ring Motor Driving a Hoist

Metropolitan-Vickers Electrical Co. Ltd

D.C. motors appeared to be more in favour with some people owing to having much better starting torques, and being in a position to vary the speed step by step, while others objected to them on account of the sparking on the commutators. A D.C. motor for use in-bye was generally enclosed in what one termed a flame tight enclosure, and if there was any risk of ignition of coal dust or gas, one motor was just as dangerous as the other. Providing they were not in a flame-tight enclosure, it mattered not whether they were A.C. or D.C., while in respect of being able to vary the speed step by step, and having better starting torques, of course D.C. was much to be preferred over A.C. At the same time, he understood that there were certain types of A.C. motors, known as cascade motors, on which they could have certain and predetermined speeds, though they could not get the step-by-step increase in speed with the same efficiency that they could get by means of the D.C. motor. Of course, each system had its merits and demerits. Generally speaking, D.C. systems seemed to be preferred for tramway working, although they relied in many cases upon high-tension A.C. systems to sub-stations from which they generated D.C. current by means of rotary convertors or other such apparatus to supply the tramway feeders. Evidently most engineers considered that a much better proposition than trying to run the trams on A.C. supply direct.

As to the great reserve of power required for an A.C. plant, that would be more or less true if people worked their plants at a low efficiency. If they found plants working at 0.4 power factor when others were working at 0.95, one could easily understand the necessity of a reserve, when large wattless currents had to be dealt with, and if one found this kind of thing he would naturally have the impression that there was some mismanagement somewhere. This condition of things could, of course, be eliminated to a great extent by installing motors that were not too large for their work, and if it was really necessary that motors should be installed large enough for future extensions, they would have to adopt other means that he had mentioned earlier to bring up their power factor. If they could keep a reasonable power factor he could not see that there was very much to worry about from their point of view, and he did not see why an A.C. plant should not be as efficient as, or more efficient actually than, a D.C. plant, taking into consideration the transmission losses and the cost of copper in D.C. working as compared to A.C. working. Therefore, all considered, he would say that an A.C. plant, well maintained with a decent power factor, was a very much more efficient plant than a D.C. plant.

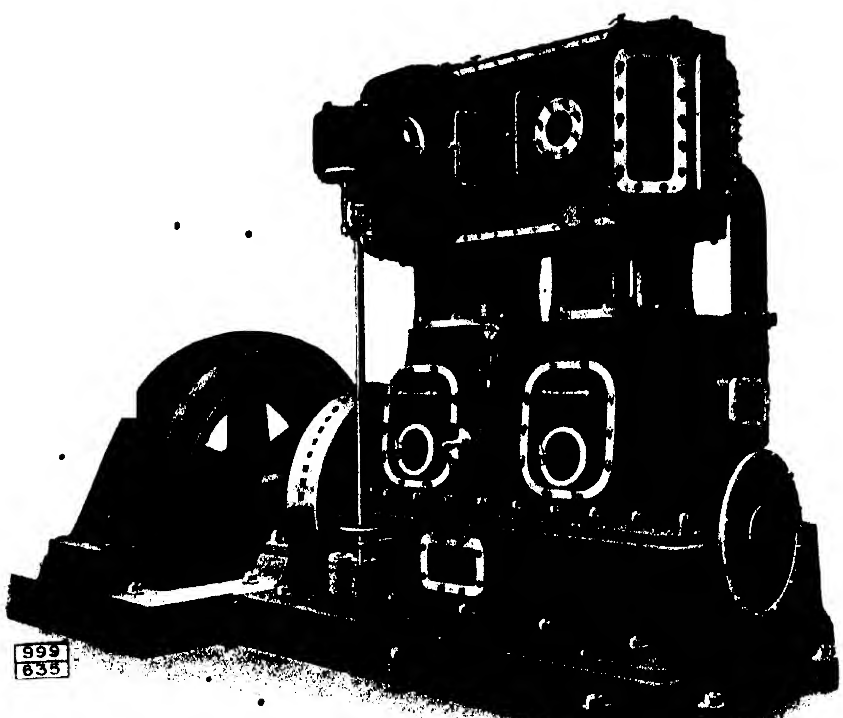
Notes on Compressed Air*

By D. H. CURRER BRIGGS, M.A. (Oxon)

I DO not propose in this short paper to enter into any technical details, but simply to place on record the results of practical tests and observations with the view of drawing further attention to, and perhaps preventing the present widespread waste and inefficiency in the use of compressed air for coal-mining purposes. It is as safe a means of providing power as can be adopted at the present time. The only real danger is that with an oil of low flash point the heat of the air in the air cylinders has been known to produce partial combustion of the lubricating oil, whereby a small proportion of carbon monoxide might be emitted with the compressed air from the machines, thus causing potential danger to life. If it be admitted that it is necessary to use power of this kind, it must, of course, be employed as cheaply as may be consistent with efficiency. There are several ways of doing this which will naturally occur to every practical engineer first, by the cheap production of compressed air by means of such power as mixed pressure turbines and rotary or high speed compressors, or gas-driven compressors worked on waste or coke oven gas; and secondly, by the most rigid supervision not only of the compressors, but of the whole of the plant using, as well as conveying, the compressed air.

Compressors

The compressors themselves, if installed by a reliable and up-to-date maker, leave little for the colliery engineer to do beyond supervision and the carrying out of ordinary running repairs. With regard, however, to the accessories e.g., receivers—these might be made to serve several useful purposes besides giving a means of "capacity"; for instance, receivers could be used as air coolers and water extractors. The heat could be extracted from the air by passing water along tubes fixed through old boilers (assuming these are used as receivers), when the water carried in the air would be deposited in the bottom of the shell, and could be let off by



High Speed Vertical Type Two-Stage Motor-Driven Compressor — *Robey & Co. Ltd.*

* From a paper read before the Midland Institute of Mining, Civil and Mechanical Engineers.

TABLE I

SHOWING VARIABLE QUANTITIES OF AIR USED BY COAL CUTTERS

Description of machine	Cu. ft. of air per min.	Remarks
2 cyl., air driven coal cutter No. 1 (1st test)	780	Pressure-drop from 40 to 36 lb. per sq. in.
Do., (2nd test)	800	Pressure drop from 39 to 32 lb. per sq. in. 380 cu. ft. per min. passed when fastened. Repaired 8 weeks previously.
Do., No. 7 (1st test)	800 and over, beyond range of meter	Has not been out of pit since new in 1907. Air pressure drop from 52 to 44 lb. at valve.
Do., (2nd test)	720	Pressure drop from 40 to 37 lb.; 130 cu. ft. per min. passed when fastened. Repaired 3 weeks previously.
Do., No. 9	7[illegible]0	Pressure drop from 37 to 30 lb. The engine allowed 120 cu. ft. per min. to pass when it was fastened.
Do., No. 11 (1st test)	620	In use about 13 years. Air pressure dropped at valve from 45 to 35 lb.
Do., (2nd test)	680	Pressure drop from 40 to 35 lb. The engine allowed 130 cu. ft. per min. to pass when it was fastened.
Do., No. 15 (1st test)	760	Air pressure, 38 lb.
Do., (2nd test)	770	Pressure drop from 45 to 37 lb. The engine allowed 140 cu. ft. per min. to pass when it was fastened.
Turbine coal cutter, air driven, No. 1 (1st test)	620	Air pressure, 45 lb.
Do., (2nd test)	620	Pressure drop from 40 to 35 lb. Leakage when fastened, 380 cu. ft. per min.; 40 yds. of hose.
Air turbine coal cutter, type S (1st test)	700	New 1916. Air pressure drop from 52 to 43 lb. at valve.
Air-turbine, No. 2 ...	400	Full load. Pressure drop from 45 to 42 lb.

means of an automatic trap similar to a steam trap. The absence of water in air mains is, of course, essential to the maintenance of good joints. It might even be possible to extract the moisture from the air by drawing it through trays of anhydrous calcium chloride, which can be used satisfactorily as a dehydrating agent. The calcium chloride thus saturated could be dehydrated by passing superheated steam through tubes laid in the trays, while leaving the tank or box open to the atmosphere, as this compound readily gives up its moisture at the reasonably low temperature of about 130 deg. C. If air drying and "after cooling" are resorted to, the air is produced in the best form for use as an agent for the transmission of power, and, in addition, some portion of the heat energy usually wasted would be imparted to the water for boiler feed purposes to give it an initial rise in temperature before entering the feed water heater, thus being not entirely lost, as is so often the case. Further, there would be no need to instal additional pumps, as the present feed pumps would be capable of effecting the necessary circulation of cooling water.

Pipe Lines and Receivers

These are a fruitful source of waste and trouble, as joints are not easy to keep in the best possible state, owing to the movement of floor and sides and the action produced by water on the joints. It is necessary to have receivers fitted at suitable intervals along all air mains, with water-extracting traps attached working automatically; and it is also desirable to instal pipes of the largest diameter possible, so as to reduce the velocity of flow and thus avoid pipe friction.

It is needless to remark how imprudent it is to endeavour to determine the leakage on a main by casual observations. Nothing short of systematic observation can give the efficient result required. A simple test of the state of the mains in use can be made by running up the pressure in the system to its predetermined height, and, when no machines are working and all "gate-end" valves are closed, after allowing the pressure to die away to atmospheric pressure, to note the time taken. The test can be automatically taken by using a registering pressure gauge, which will show by the time taken whether any fault or deterioration has occurred in the mains since the last test.

Care of Air Motors and Engines

Air-driven engines are often kept at work long after they should have gone into repair shops, not because they fail to work satisfactorily to outward appearances, but because they are consuming a quantity of air that would pay for a fitter's time many times over. To prove this point, tests were made on a few air engines, such as coal cutters and small haulages, with the results indicated in Table I, which show the very variable quantities of air used by similar machines. In all cases the coal cutting machines took a 6 ft. cut, and were presumed to be working under full load, but no method was available for testing the brake horse-power given.

In order to show what a great effect the maintenance of air pressure has on the work done by engines, I have carried out a number of tests on a two-cylinder (8 by 12 in.) hauling engine with varying pressures, taking readings of the b.h.p., i.h.p., pressure at the stop valve, and cu. ft. of free air consumed per minute. These are given in Table II, and show respectively the i.h.p. and b.h.p. plotted against cu. ft. of free air per minute and the same horse-powers plotted against the air pressure in lb. per sq. in.

TABLE II.

TEST OF 8 BY 12 IN. MAIN-AND-TAIL HAULING ENGINE.

Air pressure, lb. per sq. in.	I.h.p.	B.h.p.	Efficiency per cent.	Consumption. Cu. ft. per min.	Cu. ft. per min., per b.h.p.
20	8.65	0.15		380	
25	14.00	5.78	41.32	450	77.8
30	20.22	11.27	55.69	480	42.5
35	26.08	14.92	57.24	570	31.0

TABLE III.

RESULTS OF TESTS ON SMALL HAULAGE ENGINES ON THE SURFACE

Description of engine.		Cu. ft. of air per min.	B.h.p.	Cu. ft. of air per b.h.p.
Main-and-tail: air-turbine	(1st test)	520	6.1	85.24
Do.	(2nd test)	480	8.0	60.00
Main-and-tail: 2-cyl. double-acting (8 × 12 in.) ...		510	6.4	79.70
Do.		600	8.5	70.58
Main-and-tail: 2-cyl. (5 × 8 in.)		460	3.1	148.40
Main-and-tail: turbine		320	6.4	50.00
Do.		360	7.1	50.70
Do.		480	7.5	64.00
Main-and-tail: 2-cyl. double acting (8 × 12 in.) ...		600	17.95	33.425

These figures show clearly that the internal losses of an engine are considerable, and that if the supply pressure is allowed to fall for any reason until it comes too near the pressure necessary to overcome no-load losses, the work done by the engine is greatly reduced, in which case the haulage would be almost at a standstill. It is therefore of the greatest possible importance that the supply pressure should be well maintained.

Further b.h.p. tests have been made on the surface on small haulage engines before they were sent down the pit, and these have proved very instructive by showing the ratio of cu. ft. of free air per minute to b.h.p. given by various types of engines. The result of these tests is recorded in Table III.

Test of Pumps

The overall efficiency of compressed air is known to be low, but it is not generally realised how low it really is until tests have been carried out in practice. At this stage it is convenient to give details of a test carried out on an electrically-driven compressor working an underground pump (Table IV), the result of which shows the actual efficiency obtained. The main instruments used in these tests are simple and inexpensive when compared with the valuable information obtained, namely: (*a*) a pressure gauge, (*b*) a thermometer, and (*c*) an air flow meter. The meter is of the swing gate type, and the angular displacement of the gate is the measure of the pressure due to the velocity head or rate of flow. For practical purposes this meter is sufficiently accurate for pit use.

The great advantage of this meter is that it is easily portable, it rarely gets out of order if handled with reasonable care, and it gives direct readings in "cu. ft. of free air per min." The meter is calibrated to give correct readings when attached to a main in which the air is passing at a temperature of 70 deg. F. and a pressure of 30 lb. per sq. in.

In order to show that the company has tried to make use of the results of these experiments, it might be well to mention a few of the alterations which have been made to the plant in connection with which these tests have been taken.

Mains

For some years past the size of both trunk and branch mains has been gradually increasing, and there are now considerable lengths of mains varying from 14 to 7 in. in diameter, namely: 14 in. mains, 551 yd.; 10 in. mains, 9,107 yd.; 7 in. mains, 14,213 yd.; or about 13.5 miles of mains of 7 in. and over; whereas in 1909 there were only 11.5 miles of pipes of all

TABLE IV.

TEST OF 12 BY 12 IN. AIR COMPRESSOR WORKING A PEARN PUMP AT SILKSTONE ELECTRIC POWER HOUSE.

150 h.p. Gas Engine and Generator.

Power generated, 254 volts, 300 amperes = 102.1 effective h.p.
Total gas consumed per hr., 2,100 cu. ft.
∴ Gas consumed per h.p. hr. by gas engine = 20.5 cu. ft.

100 h.p. Motor and 12 × 12 in. Air Compressor running at 210 revs. per minute.

Power used by motor, 250 v., 300 amp. = 100.5 effective h.p.
Theoretical h.p. of air compressor running at 210 revs. per min.

$$\frac{210 \times 113 \times 2 \times 2 \text{ area} \times 23.4 \text{ lb. mean pressure (calculated)}}{33{,}000} = 66 \text{ h.p.}$$

Efficiency of motor and air compressor = 66 per cent. (theoretical).

Pearn Pump.

8 in. cylinder, 18 in. stroke, $6\frac{7}{8}$ in. rams; 21 revs. per min.; piston rod $2\frac{7}{16}$ in. in diam. Gauge pressure, 41 lb.; mean area of cylinder, 250 sq. in.; mean area of rams, 34.8 sq. in.; average mean pressure from indicator diagrams, 38.16 lb. per sq. in.

Indicated h.p. of pump:

$$\frac{250 \times 8 \times 2 \times 21 \times 38.16}{12 \times 33{,}000} = 18.22 \text{ h.p.}$$

Efficiency of pump and motor (at Silkstone):

$$\frac{18.22 \times 100}{100.5} = 18.2 \text{ per cent.}$$

Efficiency of pump and air compressor:

$$\frac{18.22 \times 100}{66} = 27.3 \text{ per cent.}$$

Quantity of water delivered by pump filled a tank (capacity, 258 gal.) in 3 min. 20 sec.

$$\therefore \text{Water delivered per hr.} = \frac{258 \times 60}{3\frac{1}{3}} = 4{,}644 \text{ gal. per hr.}$$

Quantity pumps should deliver at 21 rev.: (lift of pump 489 ft.)

$$\frac{34.8 \times 2 \times 1\frac{1}{2} \times 21 \times 6.25 \times 60}{144 \times 12} = \frac{45{,}675}{8} = 5{,}700 \text{ gal. per hr.}$$

$$\text{H.P. of pump given by water} = \frac{4{,}644 \times 489 \times 10}{33{,}000 \times 60} = 11.47.$$

$$\text{Efficiency} = \frac{11.47 \times 100}{100.5} = 11.41 \text{ per cent.}$$

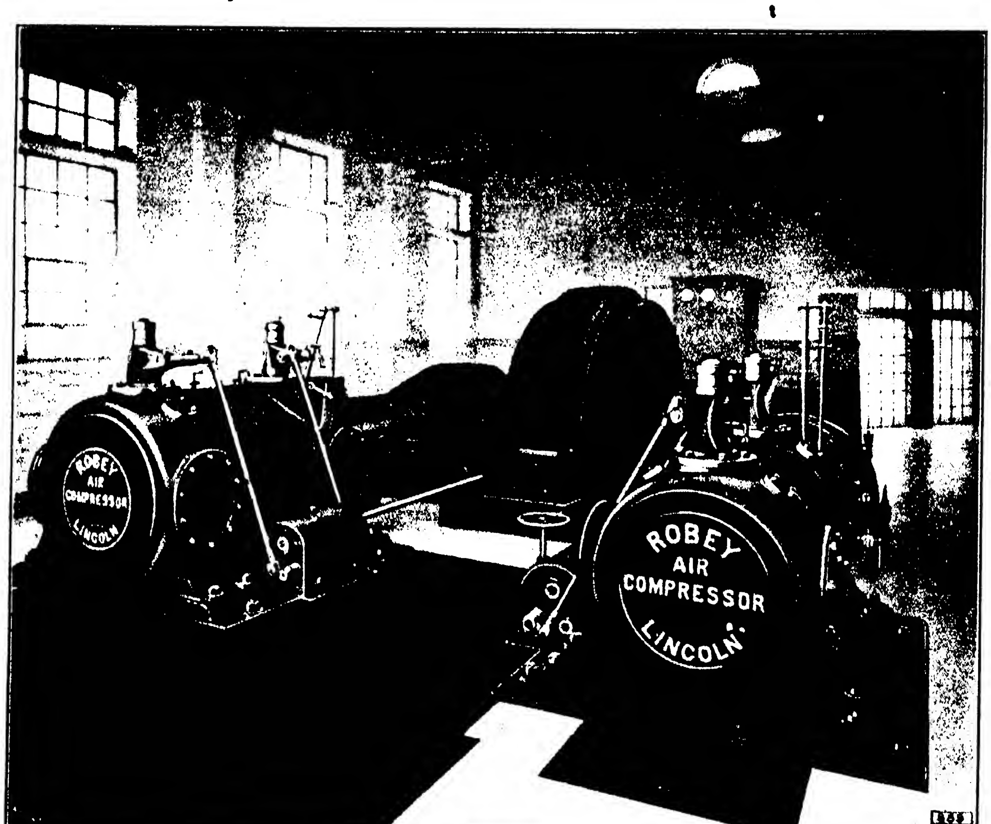
sizes. In an endeavour to further improve the air mains, a number of receivers have been installed in all the trunk mains, and also in many of branch mains, with automatic water release traps.

Pressure

In view of the pressure drop in coal cutting hose, it has been decided to use hose 2½ in. in diameter instead of at intervals for air consumption, with a view to bringing them out for repairs when the consumption is unreasonably high, and all new engines now being installed are tested for b.h.p. air consumption before going down the pit, but unfortunately no brake gear has been designed yet for testing the b.h.p. of coal cutters.

A further result of the tests made on the compressed air plant was to show that far more efficient results

The cost of the necessary instruments with which practical tests can be carried out is not excessive, and there seems to be no reason why every colliery which uses compressed air in any quantity should not be equipped with an air consumption meter of the right kind (for every electrically-equipped colliery has its own "ohm" meter) and have tests made just as regularly and systematically as is done in the case of insulation



Horizontal Type Motor-Driven Compressor

Robey & Co. Ltd.

the usual 2 in. hose, and some of the larger hose is already at work. The ordinary pressure gauge at the power station has now been supplemented by a registering pressure gauge so as to show the manager the state of his pressure throughout the 24 hours.

Engines

A system is being put into operation of testing haulers and coal cutters could be obtained by driving the main shaft pumps by electricity. These pumps were great air users, and by changing them over to electricity a good supply of air was liberated for use farther inbye. Similar changes were made with regard to large haulages, which were converted either to surface steam-driven main and tail haulages or to endless rope gears connected by a strap rope from the surface.

tests of electrical machinery. The only reason—if it be a reason for this neglect—is that with compressed air no danger results from leakage losses, but this is not so with regard to electricity, and therefore an Act of Parliament was necessary to enforce safety measures. Surely an Act of Parliament should not be necessary to enforce economy, particularly when the practice would be to our own advantage as a profession.

Coal Face Conveyors

The mechanical conveying of coal from the face has made great progress in recent years, and we describe below two different types of conveyors of recent design: one in which the "Shaker" principle is used, and the other using the continuous belt principle. Both of these apparatus are manufactured by The Mining Engineering Co. Ltd., Sheffield.

(Illustrations by courtesy of Messrs. The Mining Engineering Co. Ltd.)

THE "Meco" shaker conveyor is suitable for conveying either on the level or where the seam dips in favour of the load. The complete installation comprises a simple compressed air engine, which will operate successfully on pressures down to 40 lb. per square inch, and which consumes 100 cu. ft. of free air per minute at 60 lb. pressure.

It is fitted with a simple, quick reversing piston valve placed in a protected position at the end of, and lower than, the cylinder, in which position it is practically immune from damage due to any fall or settling of roof.

The engine can be used as a double-acting engine when the control cock is in the central position, as a single-acting engine when the control cock is placed in either the right-hand or left-hand position.

The operation of the engine when working double-acting is briefly as follows:—

Air enters the cylinder on the forward motion, and forces the piston forward. As the piston, through the piston rod and crosshead, is connected to the side rods, these latter move with the piston until one of the side rod tappets comes into contact with the reversing cam, when the piston valve is pushed over to the return position and air is admitted to the return side of the cylinder, forcing the piston back until the tappet on the other side rod comes into contact with the other reversing cam, pushing the piston over to admit air for the forward motion.

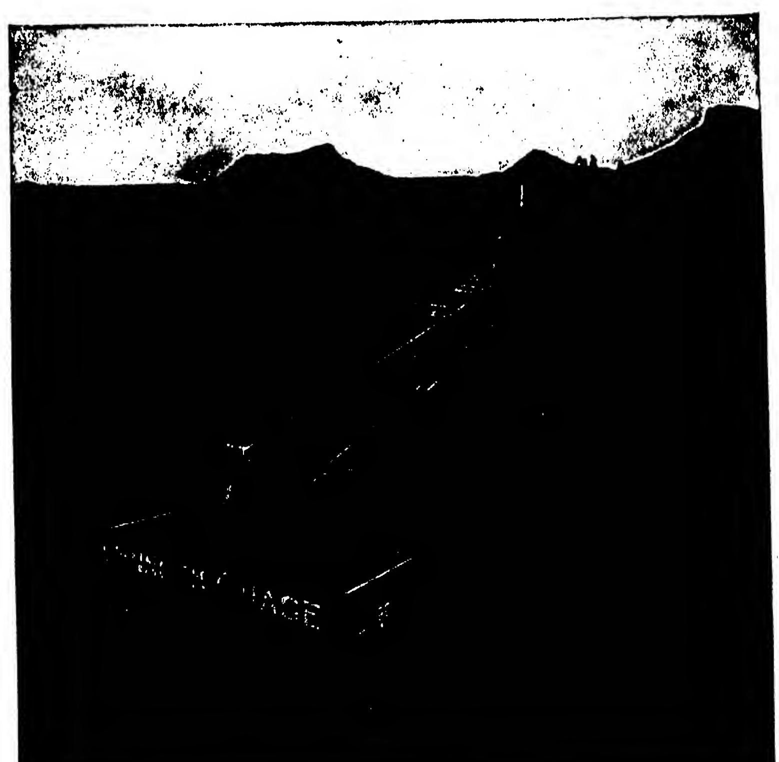
In the case of single action, air is admitted to one end of the cylinder, the side rod tappets and cams merely cutting off and allowing the air to exhaust, and the weight of the troughing being allowed to pull back the engine into starting position.

The No. 3 engine is capable of driving 100 yards of troughing, which is supplied in two sections—Nos. 2 and 3.

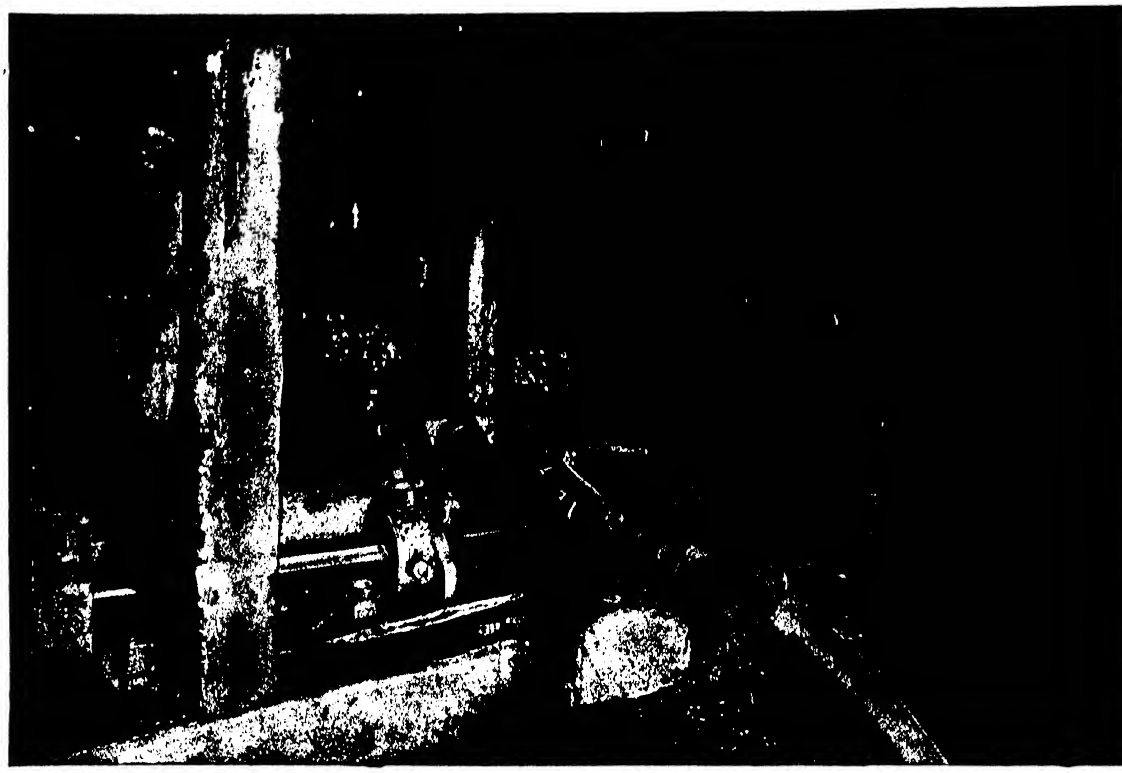
No. 2 section is for a capacity of 250/300 tons per shift; No. 3 for 350/400 tons per shift.

The extreme height of the No. 2 section troughing at the top of the rise of the roller path is 1 ft. 1½ in. from the floor. In the case of No. 3 troughing, 1 ft. 2¼ in. from the floor.

The firm also supply a larger size in their No. 3 engine for exceptionally heavy duties, but the No. 2 size is usually suitable for average conditions. Conveyor No. 3 is the one usually employed for gate road conveying, and is capable of taking the output of two No. 2 conveyors which may be delivering from on either side



Steam Driven Conveyor working on surface



Conveyor Engine in a Midland Colliery

of the gate road. In both cases the stroke can be adjusted by a simple arrangement on one side rod to give from 2 in. to 10 in. on the trough.

Arrangement of Troughing

The troughing sections Nos. 2 and 3 are supplied in 11 ft. sections with one connecting trough per 100 yards, to which the engine is connected, either by means of a plain connecting rod when the engine is placed under the troughs, or by connecting rod and cross arm driving gear when the engine is placed alongside the troughs. There is a roller path under each trough, and a roller operating in a roller frame, the action of conveying being to lift the troughing, running on the rollers, up to the top of a camel-pumped roller path, and then allow the troughing to slip back until the bump of the roller against the bottom of the roller path causes the coal to shoot forward. The roller path is not knocked out of position because the troughs are under the direct control of the engine, and the extent of the piston rod determines the length of travel of the roller in the roller path.

In single action the engine draws the troughing to the top of the roller, and then cuts off, leaving the weight of the troughs to reverse the engine by falling to the bottom of the roller path. In the case of double action, as has been explained above, air may be admitted on both sides of the cylinder, which is of great advantage when starting up under full load.

The engine is placed in a convenient place along the face, usually the connecting trough being the third trough from the delivery end, or, used single acting, the engine may conveniently be placed at the top end of the face, although in this position it is not so handy for control. When placed near the delivery end, the engine may be controlled from the gate.

The conveyor may be used either to convey along the face, swinging the last trough at the delivery end in order to deliver into a tub, or a gate road conveyor can be used, on to which the face conveyor delivers, and in some cases there are two face conveyors delivering from either side on to a gate road conveyor. The men filling off after the coal has been undercut, quickly get into the habit of setting their props in line, so that upon withdrawal of the goaf timber, the roof will either break or settle down gradually well behind the face.

For conveying purposes, the sections of troughing are disconnected, which means simply unscrewing the bolts, and are threaded in between the pit props and placed in line, the underframes and rollers being pushed forward. The engine is then pinched into position ; the whole operation can be accomplished by four men in half a shift.

Belt Conveyor

The "Meco" belt conveyor is a noiseless conveyor suitable for conveying along the level or up or down an inclination up to 1 in 4. It is per-

fectly positive in action, and conveys equally well uphill or downhill.

It consists, briefly, of the driving head, solid woven cotton belting, 20 in. broad for face work, and 26 in. broad for gate work, running on rollers at intervals of about 3 yards (the rollers being supported in self-contained roller frames), and a tension drum fitted with rotary brush for keeping clean the return belt, and with sling chains, adjusting screws for obtaining and maintaining the necessary tension.

The driving head consists of two steel side plates rigidly supported by mild steel rectangular frames. In the head are three drums (two driving drums and one idler drum), running on solid shafts and fitted with ball bearings.

The Drive

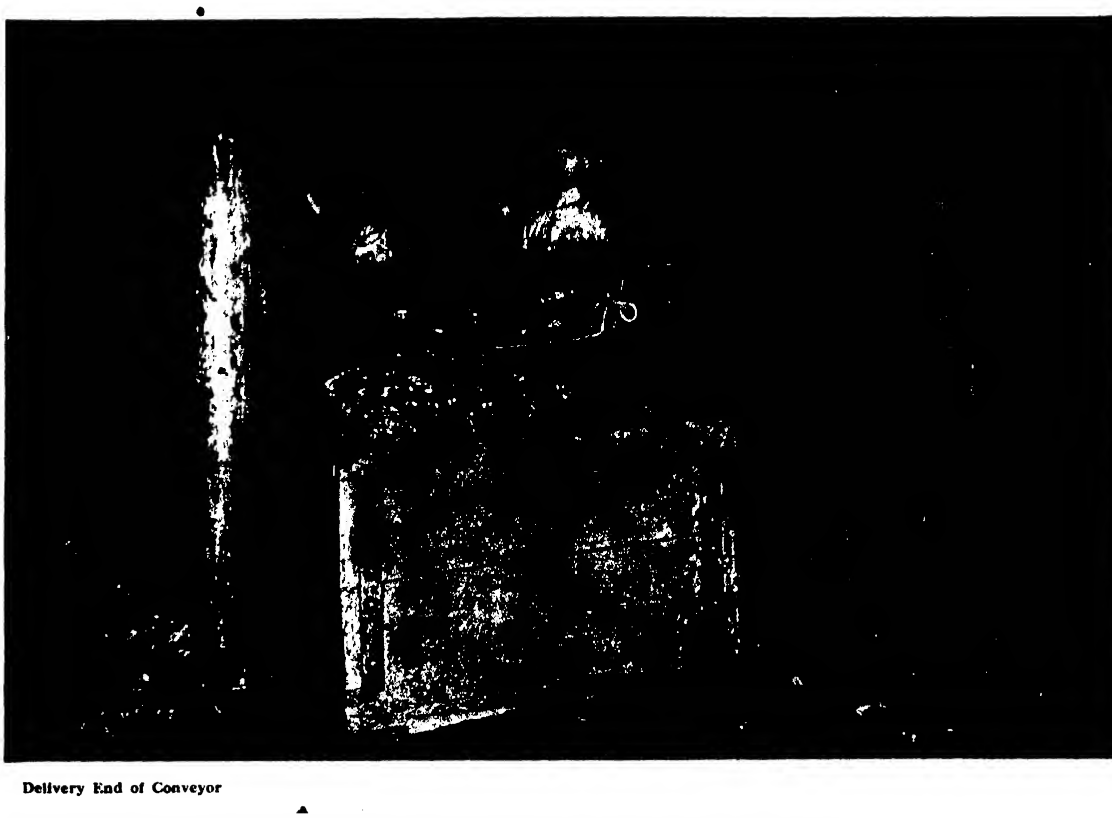
The drive is by electric motor of 8 h.p. in the case of a face conveyor, or 10 h.p. in the case of a gate road conveyor, complete with starter, connecting plug, and reversing switch, or by compressed air "Spiro" turbines, in either case mounted on to one of the side plates of the driving head in line with the gear box, which is also mounted on the same side plates, the gears being totally enclosed and running in oil. The drive is through the motor directly coupled by means of a flexible coupling to a worm shaft, which engages two worm wheels fitted with equalisers, and connected by means of flanged shafts to pinions, which in turn engage with internal gears, the internal gears being rigidly connected to the solid shafts of the two driving drums mentioned above. This system of gearing is perfectly noiseless in action, so that with this type of conveyor any roof disturbance can be plainly heard.

Usually, the faces are from 80 to 100 yards long, and the gate road conveyors up to 100 yards. The driving head is fixed at the delivery end of the conveyor, where, for starting and stopping purposes, it is under control of the loader of the tubs, and the speed of the belt is usually 100 ft. per minute. At this speed, from a 20 in. belt, an output of 50 tons per hour can be conveyed, or, in the case of a gate road conveyor with a 26 in. belt, an output of 75 tons per hour. The height of the belt from the floor is 11½ in., which is a very different matter to lifting the coal into a 10-cwt. tub.

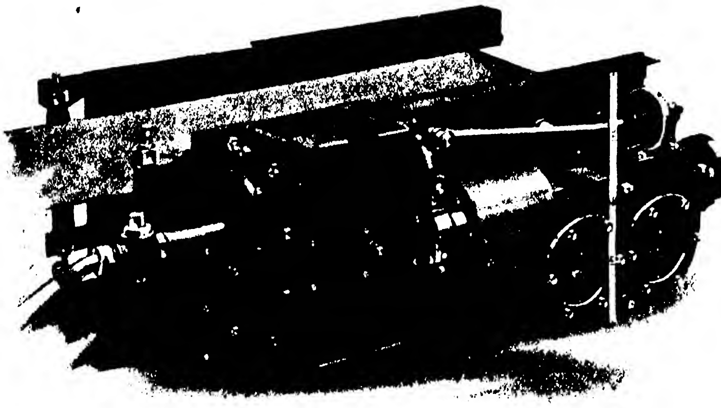
Length of Belting

For ease in flitting, the belting is supplied in 25 yard lengths, and fitted with patent quickly detachable fasteners. In flitting, the 25 yard lengths are disconnected, rolled up, and pushed forward. The roller frames, which, as mentioned above, are 3 yds. apart, are also pushed into position, the conveyor driving head and tension drum being pinched in position.

The tension drum is usually connected to two pit props by means of sylvesters, the adjusting screws and sling chains being connected to the sylvesters. It has been possible in a 2 ft. 9 in. seam for four men to flit this conveyor in an 80 yards face in 2½ hours. The weight of the driving head, complete with motor or "Spiro" turbine, is approximately 26 cwt.



Delivery End of Conveyor



Engine End of Belt Conveyor

Conveyors of both types make all the men on the face fillers of coal, effect a tremendous saving in tubs, concentrate the output to one point, will double the output with the same number of men over ordinary hand methods, or will effect the same output with half the labour, in addition to which it is only necessary to maintain a maximum of three gate roads in a hundred yards—one at each end and one in the centre,—so that the saving in ripping and denting costs, and laying of rails, is enormous. Under English conditions there have been several cases where a saving up to 3/- per ton has been effected, and the production tremendously increased by the use of conveyors.

The Keith Mine Fan

Illustrations by courtesy of Messrs. Blackman Export Company, Limited, London

OUR illustration shows a mine fan constructed by the James Keith and Blackman Company Ltd., London, for ventilating a colliery in South Wales. This fan is designed to exhaust 400,000 cub. ft. of air per minute from the pit against a static resistance of 6 in. water-gauge in the inlet drifts, and, when working under these conditions, it runs at a speed of 214 revolutions per minute, and requires about 500 horse-power.

Figs. 1 and 2 show the general arrangement of the fan and air ducts, and it will be seen that the fan is of the double-inlet type, which is the usual form for all except the smallest sizes. It is customary in England to construct a part of the casing volute of steel plates in order to facilitate the introduction and removal of the runner, the remainder of the casing, etc., being practically an extension of the brickwork of the drifts. This form of construction has been followed in this fan, though, if desired, the housings and discharge chimneys of these large fans can be constructed entirely of plates. The Coal Mines Act (1911) requires that "in every mine in which a mechanical contrivance for ventilation is used there shall be provided and maintained adequate means for reversing the air current," and Figs. 1 and 2 illustrate a simple system of dampers, whereby, at a moment's notice, the fan can be converted into a blowing-in fan, in order to comply with this requirement.

The overall diameter of the runner is 11 ft., and the diameter of each of the inlet eyes is 10 ft. There are fifty blades on each side, and each blade is riveted by a long flange to a heavy steel centre plate, while the inlet ends are riveted to a narrow shroud-ring strengthened by an angle-iron spigot. The blades are curved, both the inner and outer edges pointing in the direction of rotation, and the inner edge being arranged so that the air enters it with the minimum shock. The centre, by which the runner is secured to the shaft, comprises two conical iron castings, which are introduced from either side, and are accurately centred in the fan by means of turned spigots. Two rows of bolts, a number of which are fitted in reamed holes, hold the two castings together, and also secure the centre plate.

The external diameter of the runner over the blade-tips diminishes from the inlets to the centre, and this construction has been adopted in order to compensate for the tendency of the air entering the eyes in an axial direction to bank up towards the centre plate while it is being deflected radially outwards. The increased diameter at the inlet ends of the blades creates a correspondingly increased inductive effect at this part, and thus ensures a comparatively uniform delivery of air over the whole periphery of the runner. Apart from its efficiency as an air-mover, the design of the runner is of interest from a mechanical standpoint. The nearly triangular shape of the blades gives them great strength to resist centrifugal stresses, while the curvature provides ample lateral stiffness; so that, even when running at the speeds required to overcome the highest resistances, it is never found necessary to employ supplementary internal stays in runners of this type.

Referring again to Fig. 2, it will be seen that the fan has been specially arranged for driving from either end of the shaft through rope-pulleys. The shaft is composed of a middle section coupled to two end sections, the latter being 8 in. in diameter for the greater

part of their length, but swelled to 10½ in. in diameter at the parts on which the rope-pulleys are mounted. The middle section of the shaft, which carries the runner, is 16 in. in diameter, but is reduced to 8 in. in diameter at the journals.

The accurate alignment of the three-part main shaft, which runs in six bearings, is obviously of vital importance, and consequently special attention has been given to this point. For this reason the couplings have all been forged solid on the shaft, and the middle section has been so arranged that the runner can be dismantled for transit purposes, and re-erected on the site, without re-fitting the couplings. Furthermore, the bearings are all provided with double-adjustment sole-plates. Transverse alignment is obtained by means of the screwed stops at the side of the pedestal, and vertical adjustment is made by means of a wedge-piece operated by two lower screws in the end brackets of the sole-plate; an upper pair of screws at the end are stops to prevent the bearing from moving in a transverse direction while vertical adjustment is being made. The sole-plates of the four outer bearings are bolted directly on to the concrete or brickwork foundations; but the two inner bearings, nearest to the runner, are each carried on a pair of rolled steel joists, the ends of which are built into the brickwork of the drifts. The joists are supported at their centres by cast-iron columns, designed so as to offer the minimum resistance to the air entering the runner. The bearings themselves are

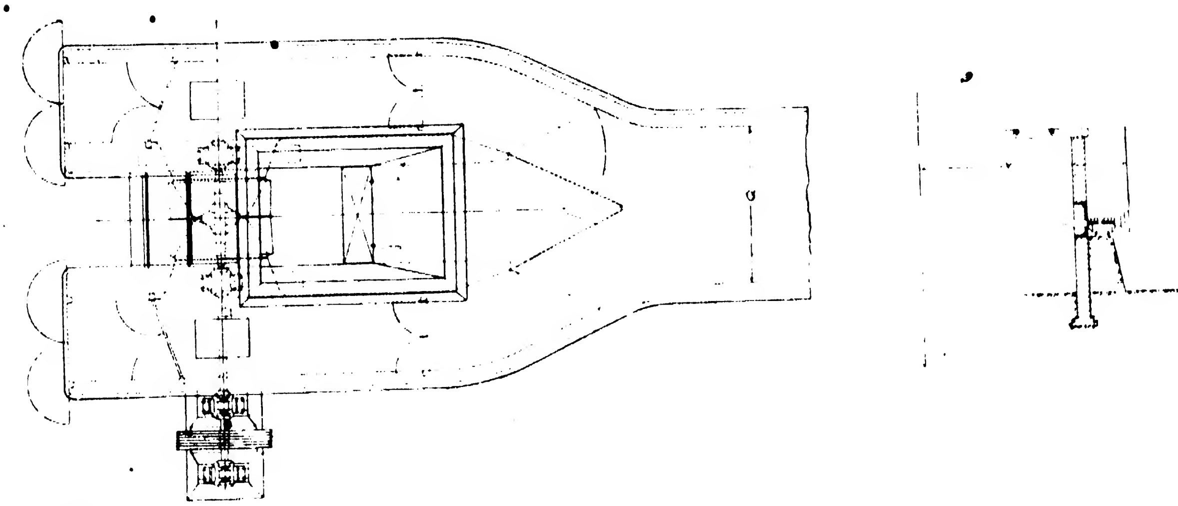


Fig. 1

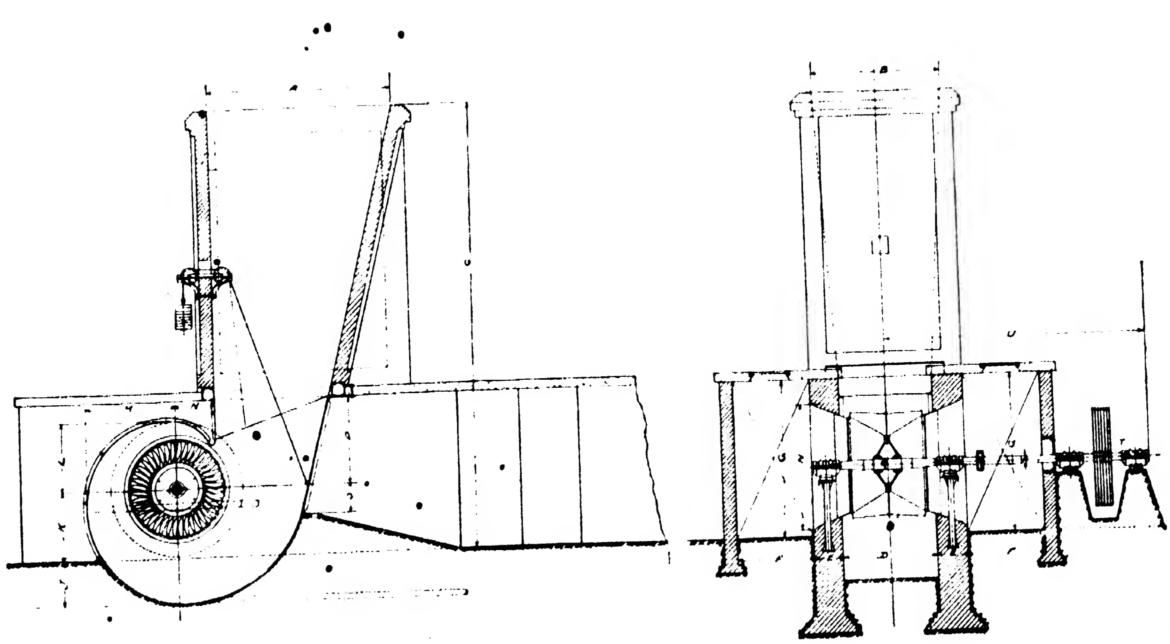
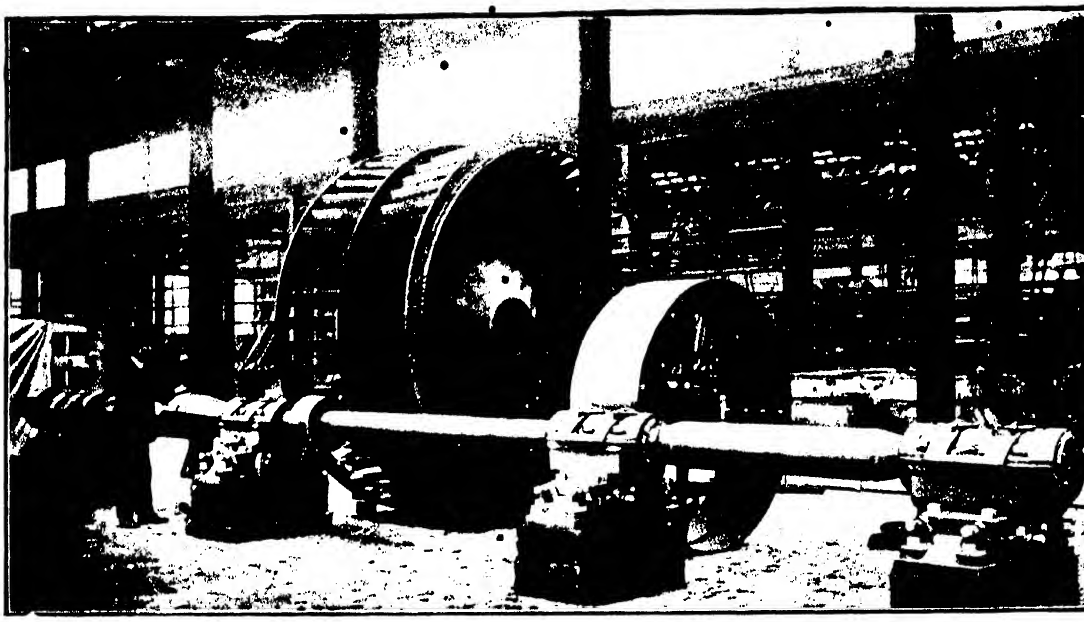


Fig. 2. Plan and Elevation sections through Keith Mine Fan



Double Inlet Keith Runner, with Shaft, Bearings and Pulley

of the ring-oiling type, and the length of the working surface, which is lined with white metal, is three times the diameter of the shaft. They are provided with large oil reservoirs, from which the lubricant is supplied to the working surfaces by double rings. Special dust-washers are fitted on each end of the bearings to prevent the ingress of dust. The pressures on the bearings are kept much lower than is usual with other classes of machinery, owing to the fact that the fan must run continuously, year in and year out, with no more attention than the periodical filling of the oil-wells.

In an installation of this kind, reliability is, of course, of foremost importance, as hundreds of human lives may depend upon its working. At the same time very careful consideration must be given to the questions of efficiency and durability in order to keep the initial expenditure and running costs within reasonable limits.

The Diamond Coal Cutter

THE Diamond Coal Cutter Co. was formed a quarter of a century ago, for the purpose of manufacturing labour-saving machinery for use in mines, and owing to the very large demand for this type of machinery, the Diamond Co. claim to have become the largest manufacturers of this special type of machinery in the British Isles.

At the present time, owing to the high cost of labour and the shorter hours worked, it is most important that labour-saving machinery should be installed in collieries wherever possible, and owing to the very rough usage mining machinery is put to, it is essential that the very best type should be employed.

The application of machinery to coal cutting renders the work of coal getting far less arduous, and consequently considerably increases the output per man. In a large number of cases machines have worked in thin seams under 2 ft. thick with profitable results which could not possibly have been worked by hand getting.

Coal cutting by machinery also enables a rapid systematic advance to be made at the coal face, and ensures increased safety for the men working the coal. Machine cutting very largely reduces the use of explosives, and in some cases where the undercut is of sufficient depth, explosives can be dispensed with entirely. Undercutting by machinery —as compared with hand getting— enables a far larger percentage of

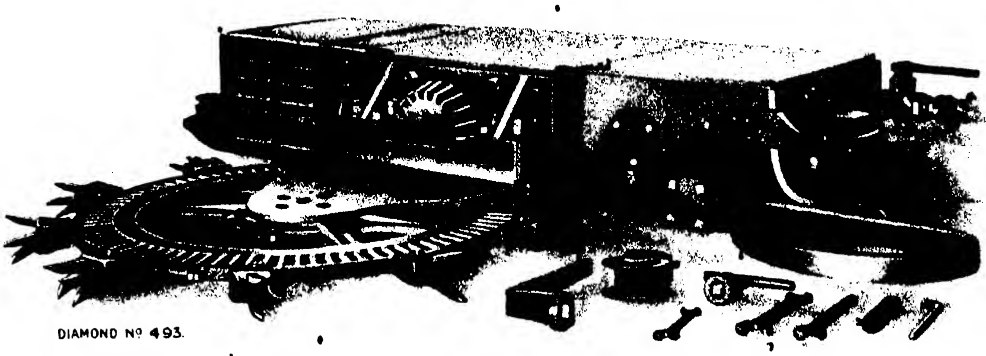


Fig 1

large coal to be obtained, by reason of the fact that a machine can cut in material such as fireclay or clod underneath the coal seam, which may be too hard to be removed by hand labour. By this means practically the whole seam is obtained in large coal.

The early Diamond Coal Cutters were of the kind known as the disc type, which are especially suitable for holing in hard and difficult conditions where the coal will stand up after being undercut. This type of machine is made to suit both compressed air and electrical power. The compressed air machines can be arranged to be driven by reciprocating engines, or, where a large power is required for very difficult conditions, the machine can be fitted with a turbine to give 40/50 h.p., as shown in Fig. 1.

For conditions where the roof is not good, or where there are slips in the coal, that render it tender and liable to break up and fall immediately after being undercut, the chain type machine is more suitable, and the Diamond coal cutter, as shown in Fig. 2, illustrates the latest, which has been specially designed for these conditions.

In a chain type machine the coal can be spragged up close to the solid coal, whereas when a disc type machine is used, the nearest point where a sprag or wedge can be placed to support the coal is from 4 ft. to 7 ft., according to the size of the cutter wheel, with the result that the coal or overlying strata readily breaks up and falls on to the cutter wheel and its support, causing breakdowns and stoppages.

The Diamond chain machine is designed so that the jib is held into the cut by means of the power of the machine. A further advantage of the chain machine is the clean undercut left by the cutting chain, as owing to the high speed of the chain and the position and small diameter of the sprocket wheel driving the chain, the cuttings are largely thrown clear into the goaf or waste side.

The Diamond chain coal cutter has been so arranged that it can be fitted with either a compressed air British spiro turbine or an electrically-driven direct current or alternating current motor. The machine can be arranged to be supplied with special fittings for carrying out heading work or for cutting on short faces if desired.

Where coal is machine cut, it is also very important to provide means for getting the coal quickly and economically away from the face, and during the last few years the system of applying conveyors in coal faces and gate roads has grown enormously. Conveyors are specially applicable for thin seams, where it is impossible to get tubs along the face.

Where conveyors are installed in large numbers, it is found that they lead to a regular system of working.

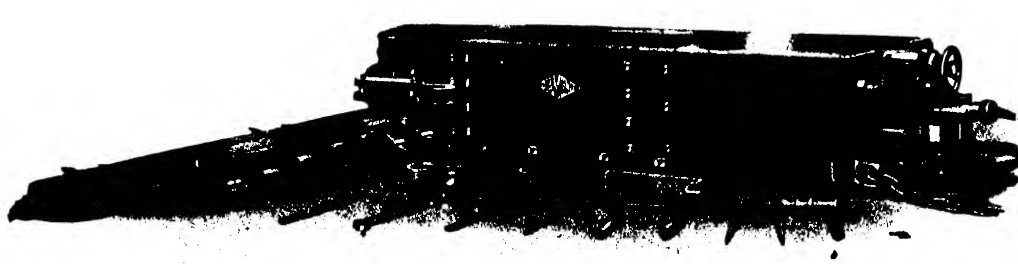


Fig. 2

The operations of cutting coal, filling off and moving over the conveyor at regular intervals cause the underground arrangements to become organised, and the maintenance of roads, supply and transport of tubs are arranged in a systematic manner for the purpose of dealing with the increased output; this system leads to increased safety on the coal faces.

The Diamond jigging type conveyor is best suited for level faces, or where there is a gradient in favour of the load. Special cradles can be supplied to transport the coal against a gradient that is not too steep. The important feature of the conveyor is its simplicity. It is a plain trough without any complication such as scraper chain or belts which get out of order and cause breakdowns.

Some Historic Notes on a Derby Firm

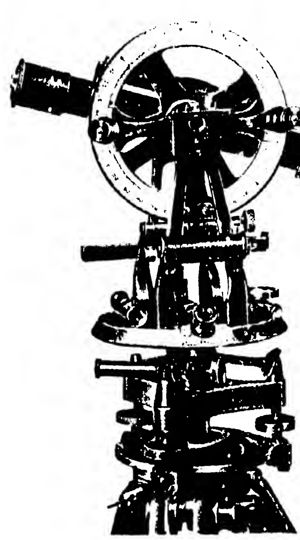
The firm of John Davis & Son (Derby) Ltd., of All Saints' Works, Derby, England, has been in existence more than one hundred years, manufacturing apparatus generally for mining purposes which may be found in practically all parts of the mining world. Their mining instruments are employed at colleges, and by lecturers at the County Council schools, for the purpose of technical education, and the leading text books on mining engineering describe their productions and illustrate their specialities.

Davis' surveying instruments are particularly well-known in the Indian Empire, helping to make prosperous that great country in surveying both the surface and underground.

It might interest readers to know that the idea for the original Hedley dial was conveyed by Mr. John Hedley (then one of H.M. Inspectors of Mines), who happened to reside in Derby, and was a personal friend of the late John Davis.

This was some seventy years ago, and it is still the leading instrument for underground surveying.

About this time, also, a Mr. Benjamin Biram, a prominent mining engineer, got John Davis to construct an instrument to measure the speed of air currents in mines.



Davis' New Pattern Theodolite

The "Biram" anemometer is a text book word, and, like the Hedley dial, is still the leading instrument.

The present form made by the firm is known as the "Davis-Biram" and this is employed all over the world where coal mines exist.

Amongst the other manufactures of John Davis & Son (Derby) Ltd., may be mentioned self-registering water gauges, ordinary water gauges, hygrometers, barometers, thermometers, mining signals, bells and relays, switches, electric blasting apparatus, miners' safety lamps (both oil and their new "Davis-Derby" patent pillarless electric safety lamp), etc.

A BRIEF SURVEY OF INDUSTRIAL INDIA

(*Continued from page* 411.)

incalculable value to the future progress socially and commercially— of the country. In future articles we will deal, in detail, with some of the principal agricultural, as well as the commercial industries, but from what has already been written, it can be readily seen that India is a land of possibilities a country of great productive wealth which only awaits development upon modern lines to secure for it a leading place among the agricultural and industrial countries of the world. Such developments are already taking place, and the next few years should witness an advance which will gladden the heart of every friend of India, and silence the doubts of her critics.

(*To be continued.*)

A BRITISH PATENT VINDICATED

Twelve years ago an American shipbuilding yard began constructing vessels on a special system known as the Isherwood longitude framing system, which was designed by a British engineer with a view to improving the strength of ships and increasing their carrying capacity. As a result of this development, a claim was made for royalties by the British inventor, and this claim led to legal action, which, after eight years, has resulted in final judgment in favour of the inventor.

Mine Surveying—Some Modern Instruments

PRESENT-DAY conditions call for labour-saving appliances in every phase of work. At the same time, the modern mining engineer considers accuracy in his surveys both above and below ground before everything else, and appreciates an instrument designed to assist him in attaining that end. Any device that will minimise mental and physical labour, or save time, is of primary importance to the professional surveyor and civil engineer, but care must be taken to ensure that the accuracy of the results is not in the least degree impaired, and by this test must be judged all attempts to secure greater speed or output, whether in the field or office. The selection of such a highly scientific and complicated instrument as a first-class theodolite calls for more than usual experience on the part of the purchaser, especially as the refinements regulating price must be appreciated before they can be justified.

To meet the demand for a well-designed, carefully made and thoroughly reliable mining theodolite, Messrs. Cooke, Troughton & Simms Ltd., of 3 and 5 Broadway, S.W.1, and Buckingham Works, York, have evolved their new "Rand Model." The special features of this improved theodolite have been determined in collaboration with leading mining surveyors at home and abroad, and mature experience in both field and workshop has been brought to bear on its design.

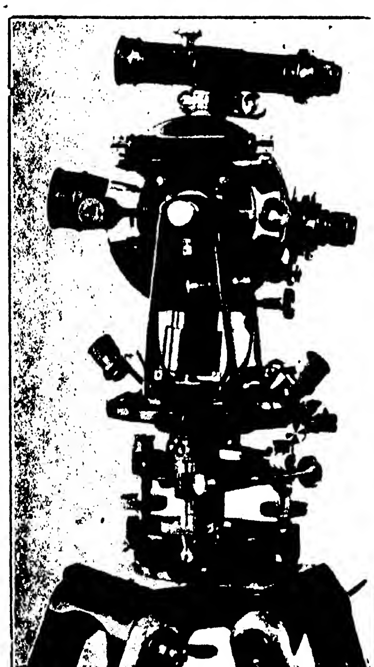
The principal considerations essential to accurate surveying underground, so far as the theodolite is concerned, may be conveniently enumerated, thus :—

(*a*) *Accuracy of Workmanship.*

The allowable limits of error in dividing of circles and eccentricity of centres have been considerably curtailed during the past few years, no doubt owing largely to the persistent work of such enthusiasts as Professor L. H. Cooke, of the Royal School of Mines, London. Such errors should not exceed the resolving power of the telescope. For instance, a telescope of 1.125 in. aperture (typical of mining theodolites) will not resolve below about 4 seconds of arc, therefore errors of the nature referred to should not exceed that figure. Of course, in larger theodolites the error is reduced proportionally.

Complete collimation of telescope (*i.e.*, coincidence between the mechanical and optical axes in all focussing positions of great importance in mine surveying where both near and distant sights have to be taken) can also be secured by a first-class maker once for all in the course of manufacture. The adoption of the internal focussing telescope, and modern manufacturing methods, practically eliminate collimation errors. This matter will be found dealt with in detail in *Engineering*, Vol. CXI, No. 2,892, 3/6/21, pages 680-682.

With special reference to the marking of diaphragms, or graticules, a well-equipped maker should be able to place these within 0.0001 inch of their theoretically correct position. An error of 0.0002 inch is discernible by an experienced craftsman in the collimator, and if stadia lines are to be used to their fullest efficiency, accuracy of the order referred to above is required in their spacing.



Cooke's Rand Model Mining Theodolite

(*b*) *Rigidity of both Instrument and Tripod.*

There is exceptionally large centering motion to the tripod head—about 2¼ in. The wing nuts may be slackened off to allow of the legs being splayed without strain, preliminary rigging up of the tripod being greatly facilitated by an hermetically-sealed circular "bull's-eye" bubble which is let into the head of the stand. After the tripod has been satisfactorily set up, the clamp nuts may be tightened, thereby ensuring absolute rigidity. By doing away with the old form of locking plate for attaching a theodolite to its tripod, and substituting a large diameter screw thread adapter, all possibility of loss between the instrument and stand on account of wear and tear and consequent error has been entirely eliminated. The trivet stage permanently attached to the footscrews will be found of great use when the theodolite has to be used in places where a tripod cannot be erected. These are points that will be appreciated by all discriminating surveyors for both above and underground work.

By slacking off special clamping screws on the footscrews, the latter are saved a good deal of wear and tear, and also the labour of manipulating stiff footscrews is avoided. For the final adjustment these screws are tightened up, by doing which the operator has the satisfaction of knowing for an absolute certainty that there is no loss or shake in the footscrews.

(*c*) *Ease of Manipulation, Cleanliness of Circles, etc.*

The telescope is of the internal focussing type, which allows of the ends being absolutely sealed. Thus dust, dirt, and water are excluded, and, moreover, the telescope can be transitted at all focussing positions. Again, the method of focussing the telescope from end of transit axis removes a fruitful source of annoyance. The milled head actuating rack and pinion is always in the same position relative to the rest of the instrument, and it is thus under all conditions ready to hand and easy to locate when working underground with bad lighting conditions. This

arrangement is patented. Sights down to 5 ft. can be taken. Clamp and slow motion screws have differently shaped heads to distinguish them by feel in the dark.

All the eyepieces and circle readers are screw-focussing, the screw threads being protected by efficient dust and dirt excluders. The clamps tighten up on to the internal collars, and thus they cannot become stuck up with candle grease, clay, etc., as the old-fashioned plate clamps used to. The footscrews are also provided with dust covers.

The removable vernier cover glasses are a great boon. When instruments are taken into the warm and humid atmosphere of a mine, the glasses generally "sweat," and in the case of fixed protector glasses, the surveyor has to wait until the moisture which has formed on the inside of the cover glasses has had time to evaporate. Hitherto, when attempts have been made by different manufacturers to make the vernier cover glasses removable, they have not been water-tight nor dirt-proof. By means of the hinged covers fitted to the Rand model, the glasses can be readily wiped on both surfaces, without any fear of their falling and breaking, or getting lost on the floor of the mine, whilst the joint is watertight after being clamped down.

When desired, a special magnifier for reading the verniers from a distance can be fitted. This is an achromatic doublet of 1 in. aperture, so arranged that the eye can conveniently read the vernier from a distance of 6 to 8 inches; the magnification is about six for average vision. The image is colourless, and the field is flat and free from distortion.

(*d*) *Compactness and Lightness.*

The conflicting elements of weight

Cooke's New Mining Dial

and strength have been balanced to a nicety, and the wonderful way in which the instrument stands up to rough usage without losing its correct adjustment demonstrates that the metal has been arranged to the best advantage.

The use of the light metal, Duralumin, and the adoption of the internal focussing telescope, have enabled weights and dimensions to be cut down very considerably.

A New Mining Dial

The greater precision now called for in colliery plans in Great Britain is reflected in the improved mining dial recently placed on the market by Messrs. Cooke, Troughton & Simms Ltd., Buckingham Works, York, which they claim to be the outcome of an investigation extending over two years.

We are given to understand that the firm referred to, who are well-known as makers of high-grade surveying, astronomical and scientific instruments, met with a demand for a better-made and a better-designed mining dial. To elucidate the elements governing an ideal specification for such an instrument, Messrs. Cooke adopted the sensible plan of drawing on the experience and advice of some of the leading colliery surveyors in their neighbourhood, *i.e.*, the Yorkshire and Durham Coalfields. They also received help from lecturers in surveying at Schools of Mines throughout the country.

The leading features of this new dial may be summarised as follows:—Vital components, such as centres, divided circles, and verniers, etc., more nearly approach the standard of accuracy associated with theodolites. The axes are entirely enclosed, and they are, therefore, dirtproof. A safe instantaneous joint connects the tripod head with the dial, or the lampcup, as the case may be. The levelling arrangement consists of a metal sphere of ample size and of robust section. Incidentally, it may be said that the plumb-bob is suspended from the centre of this ball—where there is no motion (*i.e.*, lateral displacement), of course, should re-levelling be necessary after preliminary rigging up of the tripod over a mark.

The plain sights and the telescope (the latter internal focussing, by the way) may be interchanged in a moment or two, without disturbing the "line of sight" adjustment of the dial. Last, but by no means least, the legs of the tripod are made entirely of metal (Duralumin for lightness), which removes all fear of shakiness—the bugbear with ordinary wood legs which shrink and become loose in their sockets. In addition, all three are clamped by one screw.

The New Paris Super-Power Station

INTERESTING particulars are now to hand of the huge new Paris super-power station at Gennevilliers, formally opened on the 6th of July last, and which will eventually be one of the largest power stations in the world. It is intended to supply power to the whole of the suburbs of Paris, the first unit of 40,000 K.W. having already been at work for a number of months. The general scheme propounded by the Union d'Electricite was the erection of one super-power station in Paris, with an output of 200,000 K.W., 3-phase 50 periods 6,000 volts, and the purchase and gradual closing down of the smaller stations, already belonging to six different private companies, who are merged in the amalgamation. Also the construction of a large system of mains connecting Gennevilliers to an underground ring main encircling Paris, with overhead branches to Creil, Nantes, Versailles, Corbeil, and

(*Continued on page* 452)

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

Manufacturing Wooden Tool Handles

In this article we illustrate and describe some of the most recent machines for making various kinds of wooden tool handles.

IN our January issue we published an article dealing with the great variety of Indian timbers which are available for the manufacture of the many types of tool handles used in different industries. This article pointed out that every year India imports lacs of wooden handles from foreign countries, especially the U.S.A., from which country the chief imports are hickory, ash, and beech. The author then went on to deal with the different Indian timbers in detail, pointing out their suitability for different classes of handles, and also recording tests which had been made at the Timber Testing Laboratory at the Forest Research Institute, Dehra Dun.

Machines

Bearing the above points in mind, we have collected data from some of the leading British manufacturers of machinery for making wooden tool handles, and the following brief description of some of these will give a very clear insight into the principles of the methods adopted in this class of machinery, and will give sufficient information to indicate the possibilities of such machines, and also that the principles involved are equally applicable to modifications on the machines described in order to produce any particular shape desired. As it is only possible in the length of one article to deal with a few of these machines, we suggest that those of our readers who require further information should communicate direct with the manufacturers of these machines, who would be able to supply full particulars of machines for turning out any shape of handle which may be required in quantities.

Messrs. W. A. Fell

Considering now the machines themselves, Messrs. W. A. Fell, of Windermere, have supplied us with the following particulars regarding two of their machines. The first of these is what the firm term their "42-inch automatic combined spoke and handle turning machine," for turning light and heavy spokes for artillery, wagon, carriage and motor wheels, pick shafts, army helves, sledge and hammer handles, etc., up to 42 inches in length. The average production given for this machine is about two handles per minute for heavy long work, and about four to six handles per minute for shorter articles. We understand that in turning long heavy articles such as handles for pick-axes, that it is possible within a few days' training on the machine, for an operator to be able to turn out as many as 700 handles per day, and when producing the smaller type of handle, such as hammer handles, the rate may be as much as 2,000 to 2,500 per day.

The actual cutting on this machine is done by revolving cutter-heads each carrying three knives 3 inches wide, mounted on a strong high carbon steel spindle revolving at over 2,000 revolutions per minute. A full set of cutter heads and cutters are supplied with the machines, and these can be taken off or added to in a few minutes when changing from one pattern to another; the knives can be sharpened by an oil slip when on the heads, and they only occasionally need taking off the heads to be ground.

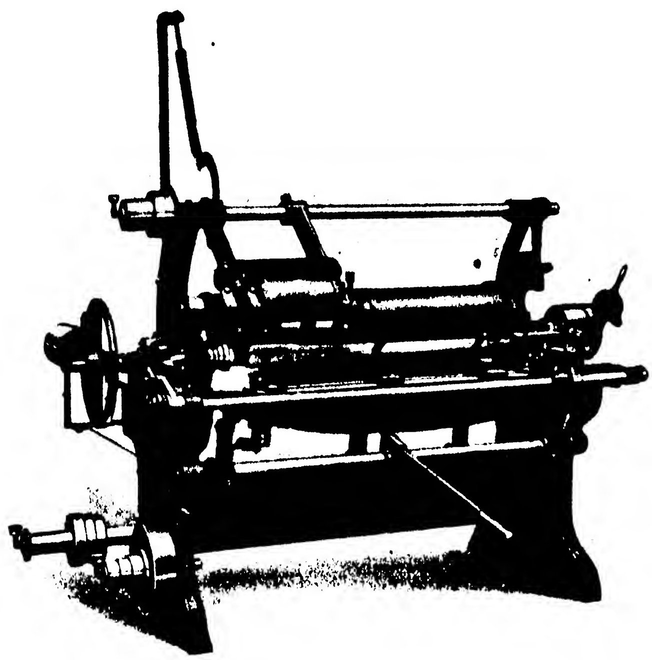
The wood is placed between centres which are carried on a table, which is moved to and from the knives by a lever, the right-hand centre headstock being loose and adjustable for different lengths of work, whilst the left-hand driving or spur centre is fixed, and, in conjunction with a belt and gears, turns the work slowly round. Any shape can be given to the work, such as flat, oval, square, hexagon, octagon, by providing a suitable cam, and different ovals in the same piece of wood can be obtained. To do this, the loose headstock is fitted on a transverse slide, which is made to move in and out according to the action of cams, which are driven by gears from the work spindle.

Centering Arrangement

A centering arrangement is fitted which enables the operator to find the centre of the wood being turned, which saves the risk of spoiling work due to faulty centering, and enables much more work to be got out of the machine. The guard covering the knives is arranged to rise and fall, thus when the table is withdrawn and the turned article is ejected, the guard falls and covers the cutters; conversely when the table is moved inwards, the guard automatically rises and exposes the cutters. This is a great help, as it removes from the operator any sense of danger, and thus materially increases production.

A three-speed change gear is fitted to the wood revolving spindle, and this is an advantage, as it enables the speed of the feed to be varied according to the length and diameter of the work being produced.

When articles of irregular outline are required, what is known as a copying lathe must be used, and for each particular shape required it is necessary to have a similarly shaped iron model, the cutters of the machine



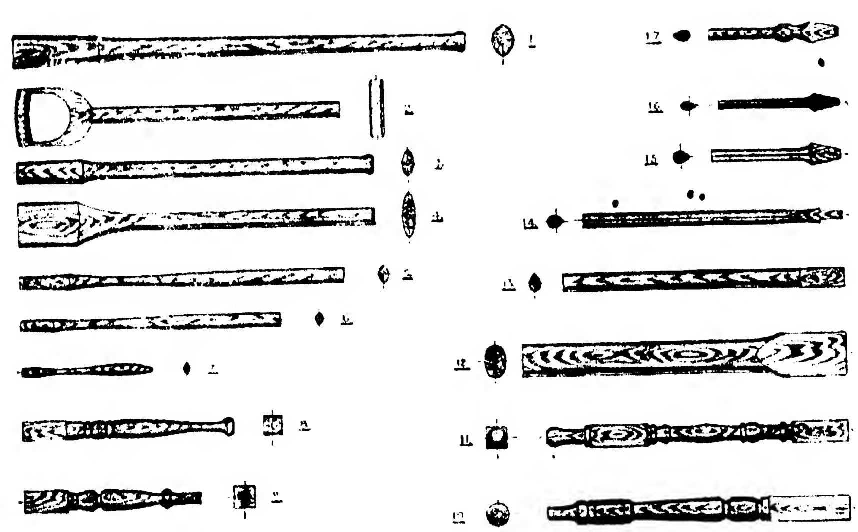
42-in. Automatic Combined Spoke and Handle Turning Machine

W. A. Fell

S.W.1., for details as to necessary machines for any particular work. This firm conduct the whole of the machine makers' overseas trade.

Considering, now, some of the machines manufactured by Messrs. Thomas White & Sons Ltd., of Paisley, the following data has been supplied by this firm regarding three of their special machines for producing different classes of wooden handles.

Taking file and chisel handles, and similar small work, the 10 in. by 3 in. variety lathe is the machine the firm recommend for this work. It is largely used in the Birmingham district, and with a competent operator a production of 24 gross per day has been produced. This the firm look upon as being extremely good. The wood is placed between the centres, and as the handle is rotated, the small front saddle travels along the bed, and in it is held a chisel which operates up and down, similar to the action of a hand turner's chisel, but the action is regulated by a template or gauge plate carried on the front of the machine, so that the handle is roughed out true to the shape. At the same time the slide which is fixed at the rear of the machine comes through, and as this carries a tool shaped out to the handle required, it gives a finishing cut and leaves the handle smooth.



Articles made on above Machine

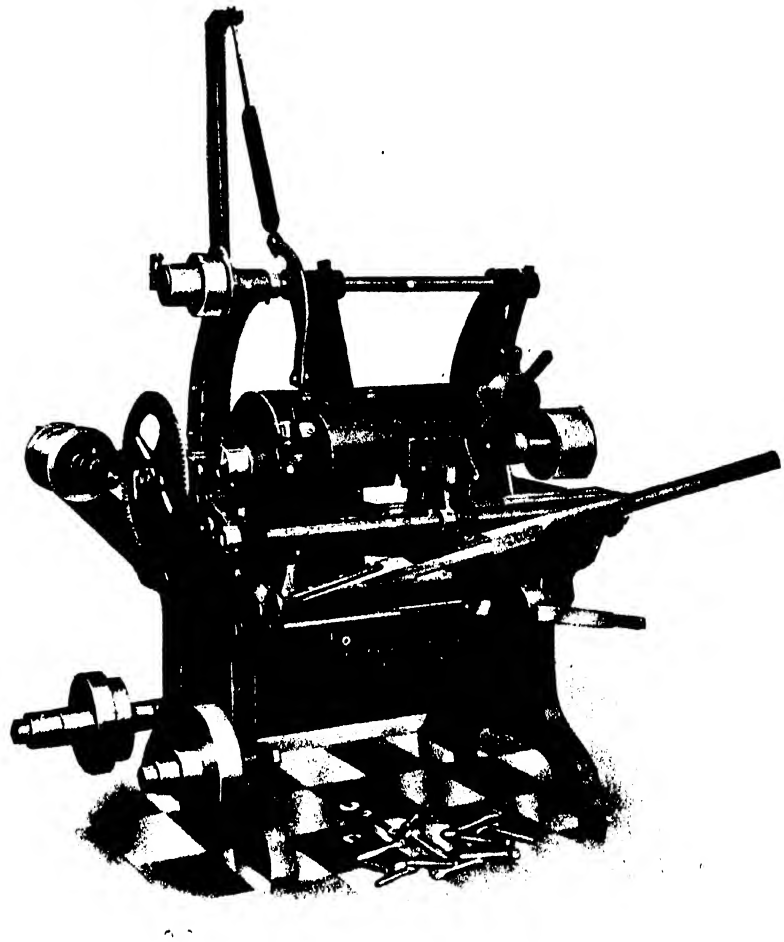
following the shape of this iron model and reproducing a similar shape on the wood operated on by the cutters. This class of machine is relatively slow in output, compared with the previous machine described, and the finish of the article is not so clean or smooth, but these disadvantages have to be sacrificed where an automatic machine is used to produce handles of irregular shape.

Readers who wish to have further information regarding this firm's machines should apply to Messrs. White, Child & Beney Limited, Broadway Court, Broadway, London,

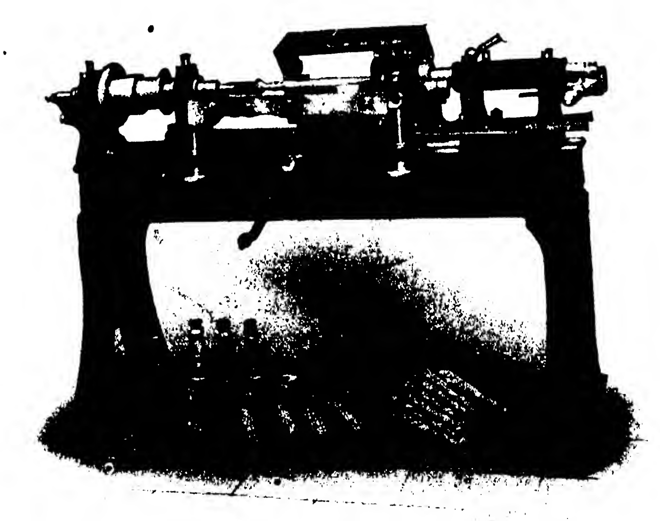
As soon as the saddle has traversed sufficiently far to the left, the operator lets go the handle, and the saddle is automatically returned to the starting position. This disengaging motion forms a patent on the machine, and among other improvements, the firm have now got a method whereby on completing the roughing stroke, the roughing cutters are lifted clear of the work, so that when the saddle is returning they do not come in contact with the wood, but as soon as they reach the starting position they are disengaged again, and drop into the position ready to start roughing the next handle. As standard equipment they also include a revolving tail centre, which prevents the end of the handle being burned while it is being turned.

The automatic oval spoke and handle turning lathe is used for the turning of pick and hammer shafts. It can also be used for round handles. Its main advantages lies in oval work. At one time it used to be customary to turn these axe and hammer handles by means of copying lathes, but in a copying lathe the cutting is done by means of gauges, with the result that the operation is not only extremely slow, but the handle is left rough, requiring a considerable amount of sanding on the sand belt. With the oval lathe the action is as follows:—

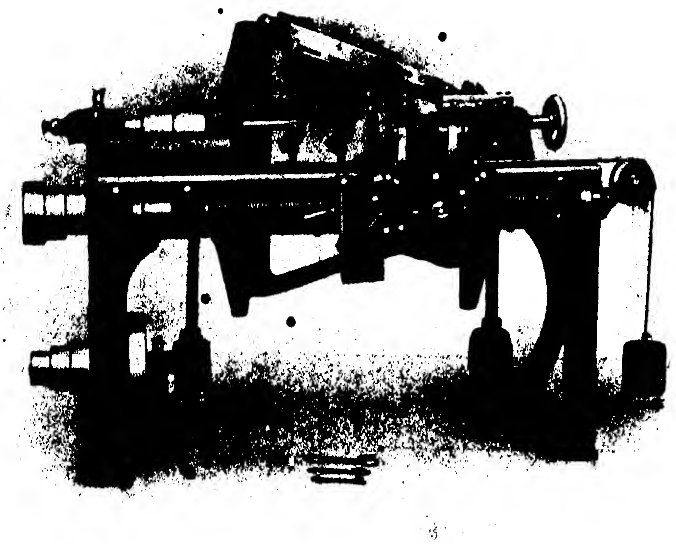
On the rear spindle cutters are mounted on cutter blocks to correspond to the total length of the handle being turned, and these are revolved at a high rate of speed. The wood is placed in the centres on the front table, and as the table is brought into contact with the cutters, the wood revolves slowly. In revolving, this action is controlled by means of cams, so that it revolves to and from the cutters, taking the profile off whatever oval is on the cam fitted to the machine. A separate cam arrangement controls the tail centre, and likewise a separate cam arrangement to the swinging cutter head. It is, however, possible to work in these ovals in such a way that, as for example in the case of navvy's pick shaft, the three ovals can be controlled on one shaft, that is, the oval on the eye, the oval at the neck, and the oval at the end. On a 12-inch hammer shaft, we have known of one gross of these being turned per hour.



Automatic Oval Spoke and Handle Turning Lathe — *Thos. White & Sons Ltd.*



Variety Turning Lathe — *Thos. White & Sons Ltd.*



Automatic Back Knife Lathe — *Thos. White & Sons Ltd*

Back Knife Lathe

The back knife lathe is used for work longer than 12 inches, as it enables a steadiment to be used for supporting the work, and at the same time gives an automatic feed to the saddle. In general action it is similar to the 10 in. by 3 in. variety lathe, with the exception that the finishing knife, in place of coming in horizontally, comes in vertically, in the form of a guillotine. This machine can be used for turning work as large as 6 in. square, or dining-room table legs and similar work.

Engineering in Bacon Factories

By W. A. TOOKEY, M.I.Mech.E.

Paper read before the Junior Institution of Engineers, London.

AT the present time a considerable amount of development is taking place in the bacon curing industry throughout the country, and, this being so, no apology is necessary in presenting a paper on "Engineering in Bacon Factories." It will be seen, as the treatment of the subject progresses, that the engineer is much in evidence, and his responsibilities are great, having regard to all the various processes involved in the utilisation of every part of the pig "except the squeal."

A certain recipe which has become a classic began with the words, "First catch your hare," and in bacon factories the first thing is to catch your pig. Any expert bacon curer will soon dispose of the fallacy held by the uninitiated that any and every pig is fit for bacon, but as this fact possesses no engineering interest, time will not be spent in expatiating upon the beauties of a well-grown bacon pig—not so much from the æsthetic as from the physical, industrial and commercial standpoint. It will therefore be assumed that the right breed and weight of pig has been secured, and is already in the sty.

Catching Pen

The animals are brought to the "catching pen" as required, and a chain sling is secured round one or the other hind leg. The other end of the sling is then attached to a lifting appliance, and the animal is slowly but inexorably elevated until the hook is engaged with an overhead rail, the pig then hanging head downwards and in this position being able to contemplate the bird's-eye, or rather pig's-eye, view that then presents itself. Indeed, it is just possible that his quiescence is due to breathless expectancy of the immediate realisation of a long foretold event, and he awaits further thrills from this, his first elevation towards the upper regions.

Before he has time to develop swelled head from his exalted position in life—although the blood pressure in that part of his anatomy is no doubt increased,—he is pushed along the track rail and is "stuck." The blood pressure is immediately relieved, and observation shows that the pig is stunned by the sudden rush of blood, and life ceases within a very few seconds. For proper curing it is important that all blood should be drained from the carcase, and for this reason mechanical and so-called humane killers, which first stun the animal and thus stem the blood circulation, are unsuitable, as well as unnecessary, for pigs.

A push along a downwardly inclined rail traverses the pig through the bleeding passage—the blood being drained off for subsequent treatment—to the entrance of the slaughter house proper. Here the carcase is

lowered from the elevated track to a scalding tank, in which it is immersed, being turned over and over until the pores of the skin have been so far opened that the hair on the ears, etc., can readily be pulled out with the fingers. The animal is then lifted from the scalding tank by means of a cradle, which deposits him on to a scuttling table for the process of dehairing. In the larger factories, where expedition is essential, machines are used for this purpose, as will be afterwards described, but, even so, the removal of hair from the animal is finished off by hand. Subsequently the carcase is again lifted on to the overhead track and passed along to the singeing machine. In this machine the animal is exposed to flames which burn off all remaining bristles and hardens the outer surface of the skin. The whole process of singeing is over in fifteen seconds, and the carcase is then pushed along under sprinklers, the water from which carries off the heat in the toughened skin from the singeing process.

The next operation is cleaning off all the dirt and sediment resulting from singeing, the carcase being passed along the track and being handled by various operatives who each has his particular job, before coming to the part of the overhead track which is called the disembowelling rail.

Here the carcase is dexterously laid open down the front from the hind quarters to the base of the neck, and all the internal organs removed. In a well-equipped factory the departments called gut room, offal room, bladder room, and lard room are close handy, in each of which auxiliary processes are carried out. Subsequently two cuts are made from tail to neck on either side of the backbone. The animal is then weighed on an automatic machine without leaving the track, and after the weight has been stamped on the carcase and entered in the log, the carcase passes to the hanging room. There the backbone is entirely cut out, and the animal—now in two sides joined only by the head is left until all the animal heat has been dissipated, and the whole carcase is at or about the prevailing atmospheric temperature. In the hanging room the heads and feet are cut off and passed along for further treatment, and the piece of flesh inside of the ribs called the steak is detached and passed to the sausage department, or sold separately, as may be required. Branding is frequently done in the hanging room.

Chill Room

From the hanging room the uncured sides are passed into an insulated chamber known as the chill room, wherein they are chilled from the temperature of the day down to 38 degrees Fah., thermometers being placed in certain of the carcases and particular parts of the animal, so that the process of chilling is thus proved. This is of the greatest importance, as "curing" demands careful attention to temperature.

The chilled sides are subsequently passed into a second insulated chamber called the curing cellar, for either "wet" or "dry" curing.

Dry cure is carried out by stacking the sides eight or ten deep on oak boards, with dry salt covering the flitch, oak boards being put between each side, and certain precautions being taken to obtain the desired end. This process is not in itself a matter of engineering interest, and will therefore not be described.

In the wet cure the sides are immersed in pickle tanks, and this process involves the use of pickle pumps for filling and emptying the tanks for circulating the brine to an elevated brine tank, and for the mixing of green pickle with red pickle, maintaining the requisite degree of saltness, and for keeping the whole in good condition.

From the curing cellar the sides of bacon are taken into the baling room for packing and despatch, and in every factory there is another department where the sides are smoked in special smoke stoves.

This brief epitome of the various processes will suffice for giving a general idea of the production of bacon in factories, and attention will now be given to the engineering features which every such factory possesses.

Taking the points in order, there must be ample supplies of hot water for scalding, effective system of overhead track bars, copious storage of cold water for sprinkling and washing down; a suitable sewage disposal system; ample power for the refrigerating plant; an effective system of illumination for the chill room and curing cellar, where no daylight is permitted to enter; an adequate system of ventilation and circulation of air by means of fans in various parts; machinery for dealing with the plant for the preparation of making lard and sausages; the preparation of poultry food from the blood and "digested" flesh and bones, etc., etc. Each of these could well form the subject of a separate paper, and all that can be done in the case of the present lecture is to give certain examples, such as have been under the notice of the author in connection with factories in which he has been engaged as consulting engineer.

Styes

The simple form of sty is one in which there is little engineering interest, but in some bacon factories the gates are double hinged, that is to say, they may be opened to swing not only inwards or outwards, but also from either the right or left hand, thus permitting expeditious handling of the pigs either when entering or leaving the styes. In some factories the pigs are made to ascend a slope to the catching pen, but in others the whole factory is laid on the level, excepting the loading platforms.

Pig Hoist

The elevation of the pig in the catching pen is effected by different means, depending upon the size of the factory and the number of pigs to be dealt with in a given time. In the smallest factories, chain block, or even rope block tackle is used. In others a hand wall hoist is installed, so that one man only can do the lifting, and in larger factories it is usual to have a continuously running machine to which the sling chain around the hind leg of the animal can be attached, thus calling for no human power in the actual lifting. There are two types of continuous mechanical lifters, one is that in use at the St. Edmundsbury Co-operative Bacon Factory at Elmswell, Suffolk. This is an elevator of the chain type, with projections to which the hook or ring of the leg chain is attached. The motive power is obtained by a small electric motor, and the delivery of the live pig on to the overhead rail is quite automatic, as the elevator is so arranged that at its highest point engagement is made with the track rail, the pig being left suspended while the projection on the elevating chain returns again to ground level ready for the next animal. In some large factories a pig wheel is often used this being a circular plated disc having four projections at 90 degrees, to which the leg chains are attached. The operator hooks the loop on to one of the projections, and the pig is thus deposited on to the track rail. The wheel can be made two-sided when dealing with an enormous

quantity of pigs. The men in the sticking stye have no difficulty in keeping the supply of pigs coming forward just as fast, or a little faster in fact, than the slaughter house staff can deal with them. Much depends of course upon the original planning of the lay-out, and the proper co-relation of the various operations. The Elmswell factory was originally planned for 750 pigs per week. It is now dealing with well over 1,000, and extensions are in hand for twice this number.

Tracking

The type of tracking varies in different factories. In those in which pigs only are killed, the usual hog rail is made from round bar iron about 1¾ in. diameter, supported at every two feet or so by cast-iron brackets from overhead joists. The switches are hinged, the switch itself being let into the forked ends of the main bar and swinging on a pin forming the hinge. The other end of the switch is shaped in the form of a mortise, and fits snugly, so that the hook carrying the animal as it passes along the rail meets with no projections, all joints being made " down the track."

Another type of tracking is rectangular bars of about 4 in. deep, ½ in. thick, the top edges being rounded, and the supporting brackets being bolted in the lower half of the depth. Care is, of course, necessary to leave one side of the whole track bar free, and all switches should be easily operated.

Scalding Tank

The scalding tank is usually an iron cistern with steam coils at the base, carefully arranged to provide efficient drainage. The end of the coil is trapped, and is usually fitted with a valve to short circuit the trap when first starting up.

The cleaning machine is one example of many, and has the advantage of occupying little space, while dealing with eighty pigs or so hourly. The water sprinklers and the pig revolving mechanism are against the roller knives.

From the scuttling table the pig is no longer slung by one leg, but the hocks are slit, and a gambrel passed through. At the centre of the gambrel is the hook which engages on the track rail.

In the Elmswell factory the pig leaving the scuttling table is lifted to the track mechanically, and the track itself is lifted slightly, so that the pig is made to slide along the bar by its own gravity to within a few feet of the singeing furnace. It should be noticed that at this point a switch in the tracking is usually provided, as the animals intended for pork rather than bacon, are not singed, but passed straight forward to the disembowelling rail.

Singeing

For the singeing process there are many types of machines, coke-fired, gas-fired, oil-fired, horizontal, vertical; brickwork settings, ironwork settings, gas-fired saddle-shaped shields, and even the simplest form of plumbers' brazing lamps. It is intended to describe the oil-fired furnace, and this only very briefly and generally.

The singeing furnace as installed at Elmswell consists of two firebrick-lined wrought-iron shells, standing vertically from a platform carrying the oil burners. The two shells are drawn apart by one lever, and the pig is pushed into the centre against a stop by another lever. Reverse movement of the first lever then brings the two firebrick shells together in close quarters around the carcase, and at the same time the oil burners, fed with pulverised residual oil by the pressure of dry steam, shoot the flames upwards from the platform right through the vertical casing, a cowl and chimney carrying off the products of combustion.

Another movement of the operating handle parts the shell, the pig is then pushed mechanically out of the furnace and underneath the water sprinklers on the exit side of the machine. Another animal takes its place in the furnace, and the operation is repeated.

Water Sprinklers

The water sprinklers call for little comment—they are merely metal containers perforated on the under side, and the sprinkler close to the furnace is usually of sufficient length so that two pigs can be drenched at the same time. Further along the track bar other sprinklers are used, one for each animal, so that the process of cleaning can be carried out, the water washing away all the dirt loosened by the hand-operated scrapers.

The process of disembowelling is passed over as presenting no engineering interest.

(To be continued.)

THE BENGAL-NAGPUR RAILWAY

PRESIDING at the 64th annual general meeting of the Bengal-Nagpur Railway Company Limited, on November 2nd, Mr. Robert Miller was able to give a favourable account of operations during the year 1921-22. The gross earnings for the year were Rs. 677 lakhs, an average of Rs. 482 per mile per week and Rs. 5.63 per train mile, the highest on record, while the expenditure was Rs. 4,84,29,146, thus absorbing 71.53 of the gross earnings. The total number of passengers carried increased by 1,198,909, or about 6 per cent., but the amount received was less by Rs. 2,79,659, or about 1½ per cent., the decrease being attributable to a decline in long lead traffic. On the other hand, goods traffic declined by 106,507 tons, or about 1½ per cent., but the freight revenue increased by Rs. 16,13,218, or 4½ per cent. The increase in working expenses is attributable to the continued rise in wages paid and the comparatively high cost of materials, and, principally, to more broad gauge engines and wagons having been repaired. Taken all in all, the Report is by no means unsatisfactory, and it is confidently expected that better results will follow from the current year's operations. It may incidentally be mentioned that the Bengal-Nagpur line object to the wagon pooling arrangement, on the grounds that their goods wagon stock is maltreated on other lines, and consequently calls for extensive repair on reaching the home line. The Indian Railway Conference Association have, however, extended the wagon pooling scheme for three years. Mr. Miller also pointed out that the Bengal-Nagpur Railway receives most of its revenue from the carriage of coal and minerals, and from agricultural products. With regard to coal, he was able to say that great progress had been made in opening out the Karanpura and Talchir coal-fields, and in this connection a branch line from Cuttack was being built. The opening of the Talchir coal-field, he added, would be particularly useful, as this coal-field was situated some 250 miles south of the Bengal coal-fields, and would provide cheaper coal for working the southern section of the railway.

The Lincoln Automatic Arc Welder (ii)

The following article is a continuation of that appearing in our February issue and the references to the machine parts refer to the illustrations in the February issue.

An end view of the clamping arrangement for longitudinal seams is shown in Fig. 5.

A_1 and A_2 are chrome nickel steel bars designed to work on a swivel at one end, and arranged with a cam and lever arm to exert necessary pressure for bringing the work into close contact with the supporting bed. B_1 and B_2 are longitudinal copper fingers serving the two purposes of gripping the work and assisting in dissipating excess welding heat. C is a copper plate introduced beneath the seam to be welded, serving to prevent the molten metal adhering to the support, and also to act as an additional cooling medium for the water-cooled columns D. E is also of chrome nickel steel, and is used for assisting the support of the work in hand. G is an angle iron arm extending from the supporting column of the automatic attachment, and at right angles to it, while F is a section of a circular item set up and clamped and ready to be welded.

It is necessary to employ the clamping and cooling apparatus in conjunction with the welder, in order that the thinner metal will not collapse under the intense heat of the carbon arc, and to carry off that heat. The clamps also serve to retain the work in a fixed position, and prevent any chance of buckling on thin plates. In addition to the compression offered by A_1 and A_2, they also play a small part as barriers in protecting the carbon flame from possible fluttering and whipping about, due to stray air currents.

When head seams are to be welded on such circular items as oil drums, range boilers, kegs, etc., the longitudinal clamp is dispensed with, and a turntable employed for revolving the work beneath the arc. This piece of apparatus for all intents and purposes resembles the turning device on a boring mill. The table is supplied with a clamp and adjusting screws for bringing the surface to be welded into the path of the arc. A ⅛ h.p. motor drives the table at the desired speed, and speed control is effected through two worm gears, one with a gear ratio of 80 to 1 twelve pitch, and the other 100 to 1 ten pitch. The speed control on the motor is made through a rheostat, and any desired speed from 1,750 r.p.m. to 3,000 r.p.m. can be had at will. The minimum speed of travel on the turntable is one turn in eight minutes, and the maximum one turn in two minutes.

The above covers the various pieces of apparatus necessary to weld both flat seams, lap, flange, or butt and head seams, when two or more thicknesses are to be joined.

Starting his working day on manufacturing, say, for instance, oil drums, the operator would place a rolled cylinder on the supporting arm, adjust the job to the desired place, and clamp down. The next operation would be to swing the welding arm into place, and make the necessary adjustments to ensure that the welding flame would advance along the seam to be welded. As the ends of the cylinder would resemble a butt joint, with the exception that a small space is left clear between them,

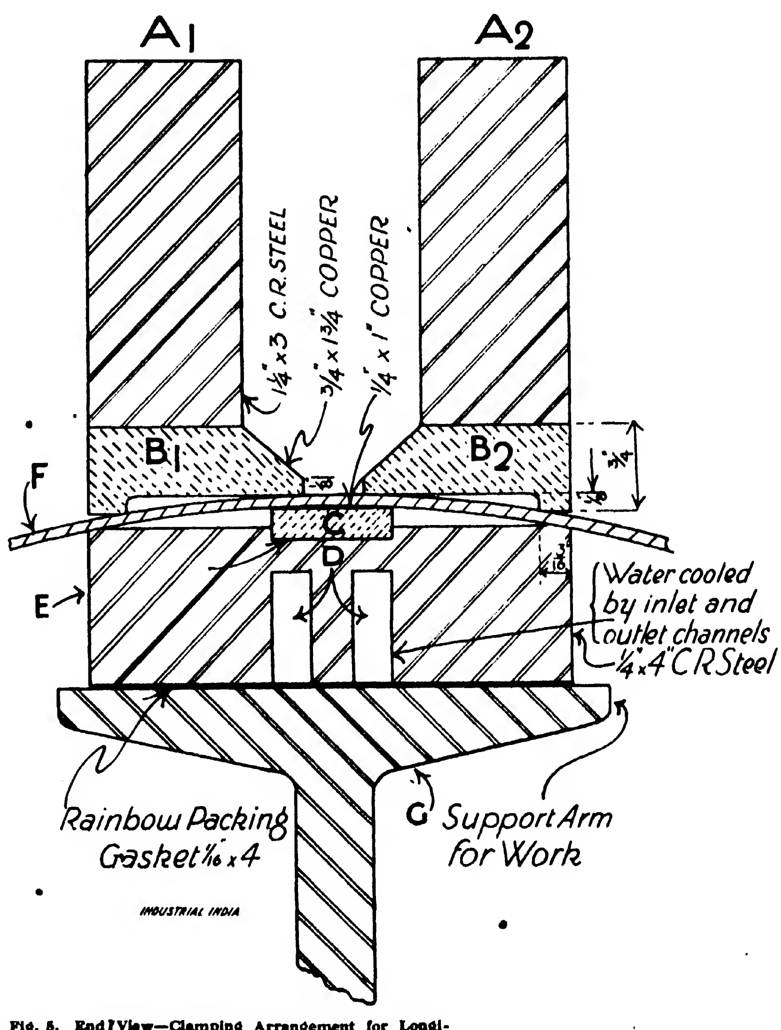


Fig. 5. End View—Clamping Arrangement for Longitudinal Seams. For use with Automatic Welder

lengths of filler wire would be laid along this opening, end to end until the desired length was reached.

The motor generator would then be brought up to speed and by means of diverter switches L and field rheostat H (Fig. 1), the current adjusted to a predetermined value. This will be governed by the thickness of plate to be welded. The operator would then adjust by means of rheostats E and F (Fig. 3) the desired speed of travel for the arc. This speed is also predetermined, and depends largely both on the thickness of plate to be welded and the current being employed at the arc. The welding operations are now ready to be started. By pressing the push button O (Fig. 3), the motor J starts up and feeds the carbon down until it touches the work when the automatic relays C come into play and reverses the direction of rotation of the motor, causing the carbon to be withdrawn, and thereby establishing an arc. When the arc is struck, clapper switch H closes, and starts up the carriage motor N.

The automatic relays C operates the motor J to either feed the carbon down or up. This depends on two things, on the voltage across the arc, and the length of arc which determines the voltage. This was pointed out earlier on in the discussion of electrical characteristics of the welding generator. As the carbon pencil burns off in operation, the relays operate the motor to feed the carbon down until the proper length is obtained. If, on the other hand, however, the carbon approaches too close to the work, and the voltage becomes very small, the relay comes into play and reverses the motor, causing the carbon welding pencil to be drawn away from the work until the proper arc range is obtained. This operation continues automatically until the seam has been welded or the operation is otherwise stopped. If only one automatic is employed in the shop, it is the custom to turn out a number of welded cylinders, and then to start in on the heads.

When the heads are ready, that is the dished ends, they are pressed into the ends of the cylindrical drum, and the hoops put on, the drum is set on to the turntable, adjusted for position, and the welding arm brought into alignment. The speed of rotation is set, the welding current increased to cope with the increased area of metal to be welded, and the turntable motor started. One of the two switches B is then opened, cutting motor N out of the circuit. The only motor required for welding head seams, so far as the automatic attachment is concerned, is motor J. The same operation is then repeated as for welding the flat seam.

The electrical connections are not shown. They are, however, comparatively simple. Essentially, power for the small motors is taken from the source of generator excitation, and power for producing the electric arc is received from the terminals on the rear of the welder switch panel and passed through the clapper switches, automatic regulators, etc., through the arc, and returned to the generator, completing the circuit.

The information given above is of interest to the engineer, but the thing the works manager wants to know is, what does it cost for capital outlay, and what speeds of welding, and welding costs, can be guaranteed? This can soon be shown. The complete equipment described above is of sufficient capacity to weld any thickness of sheet steel plate or black iron without putting it through a pickling process of from a minimum thickness of 26 gauge to ½ in., either butt joints or added thicknesses totalling ½ in. The initial outlay will be in the neighbourhood of £1,500. This machine is sufficiently large to weld complete 65 imperial gallon oil drums per day having a shell thickness of 12 gauge and four added thicknesses on the heads, totalling ½ in. Assuming that the machine is in operation 80 per cent. of the working day, the cost per drum should not exceed two shillings. This is based on power at $1\frac{1}{2}$d. per K.W.H., labour at 2/6 per hour, electrodes or filler wire at 4d. per pound, and carbon pencils $\frac{3}{16}$ in. diameter and 12 in. long at 5d. each. The actual speed of welding is at the rate of 90 feet per hour on the longitudinal seam, when 165 amperes across the arc is employed. The kilowatt input of the motor generator set will be 9.6 K.W.H. at 35 volts potential across the welding circuit.

The speeds and costs of welding will vary with the type of joint, thicknesses of added metal and current employed in the arc. Fig. 6 shows the four types of joints run up against in commercial practice, and the writer will endeavour to give a few figures from charts and cost data placed at his disposal, showing the information the executive is likely to be interested in.

Fig. 6A. On ¼ in. plate the speed of welding is 35 feet per hour, current used 300 amperes in the arc. Effective feet of welding turned out, 28 feet per hour, at a total cost based on figures previously given, of $2\frac{1}{4}$d. per foot welded.

On 26 gauge the speed will be in the vicinity of 250 feet per hour, at corresponding reduction in total cost.

Fig. 6C. The cost slopes off considerably owing to the fact that the work is much more simple to set up, and because the cost of filler wire is dispensed with.

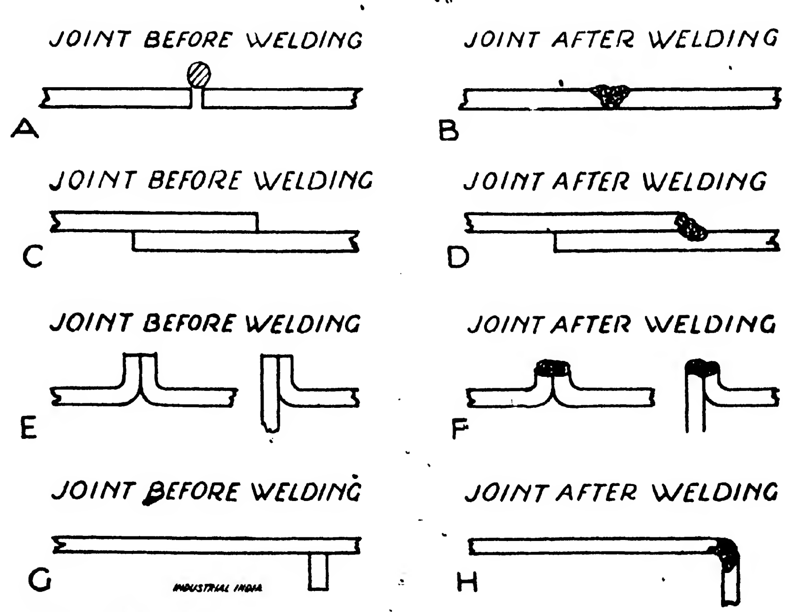


Fig. 6. Types of Welds

On 18 gauge the speed of welding at 120 amperes is 175 feet per hour, giving an effective speed turned out of 140 per hour, and at a total cost of a halfpenny per foot welded. For $\frac{3}{16}$ in. plate, the speed at 250 amperes is 75 feet per hour, giving an effective speed turned out of 60 feet per hour, and at a total cost of three-farthings per foot welded.

Fig. 6E. On two added thicknesses of 12 gauge the effective welding speed at 250 amperes is 100 feet per hour at a total cost of a halfpenny per foot welded.

Fig. 6G. On 14 gauge plate welding, the corners, the effective welding turned out is 112 feet per hour, of 225 amperes in the arc, and at a total cost of something less than a halfpenny per foot welded.

If there are any questions which our readers would care to have answered, we shall be pleased to do so.

Recent Textile Machinery Developments

The following description of two recent textile machines was omitted from our review of the Manchester Textile Machinery Exhibition in our last issue.

The data and illustrations for this article have been supplied by courtesy of Messrs. Cook & Co. (Manchester) Ltd.

Lap Testing Machine

THE question of "regularity in the thickness of laps" used both for waste and cotton spinning cannot be be too carefully examined. Hitherto it has received somewhat scant attention, whereas in carding and spinning rooms where sliver, rove and yarn are available, more or less useful tests are obtained as a guide to control the regularity of the finished yarn. In the Scutching room, however, the most sensitive test is confined to weighing a short length of broad lap—one yard long for example. Even then, when the operation of separating this length with cleanly cut edges has been satisfactorily accomplished, the regularity of the enclosed portion still remains unknown. It is evident that although a test of this description may register a correct weight for the total bulk placed on the scales, yet it does not follow that a uniform sliver from the carding engine will be the outcome. For example, assuming the aforesaid one yard of lap weighs 12 ozs., and is again subdivided precisely into four divisions of 9 in. long each, which register 3 ozs., $3\frac{1}{4}$ ozs., 3 ozs. and $2\frac{3}{4}$ ozs., the average is therefore

$$\frac{3+3\frac{1}{4}+3+2\frac{3}{4}}{4}$$

= 3 ozs., which is correct; but there is a variation of $3\frac{1}{4}-2\frac{3}{4}=\frac{1}{2}$ oz.; or

$$100\left(\frac{\frac{1}{2}}{3}\right)=16\tfrac{2}{3}\text{ per cent.}$$

Given a draft in the carding engine of 100, it is not difficult to realise the effect of this $16\frac{2}{3}$ per cent. variation in lap thickness on the 100 yds. of ensuing sliver, which, again, is drafted into 3,150 yds. of 5 hank roving, representing over 13 miles of 38's yarn.

The special test of weighing short lengths of lap is performed at comparatively rare intervals, for generally it is considered sufficient to weigh each *full* lap as delivered from the finisher scutcher and allow a maximum latitude of $\frac{1}{2}$ lb. under or over the normal weight. In other words, a 30 lb. lap is considered suitable for the carding engine when it does not exceed $30\frac{1}{2}$ lb., or weighs less than $29\frac{1}{2}$ lb. In this case the total variation is understood as

$$100\left(\frac{30\frac{1}{2}-29\frac{1}{2}}{30}\right)=3\tfrac{1}{3}\text{ per cent.}:$$

but, as has been explained, the representation is a delusion.

This crude method of testing has prevailed in the scutching room for a full century, but at length a simple machine has been introduced which registers the variation of infinitesimal portions in the length of lap. The apparatus embodies an extremely sensitive regulator that adjusts itself to the *average* thickness of lap passing through; when, by means of levers carried in anti-friction bearings, the resultant indications are recorded on a paper blank divided into spaces of length in feet and weight in ounces per yard respectively.

The lap to be tested is placed on the top of two delivery rollers, and the edge of the fleece guided between the regulating rollers. The rotary movement of these regulating rollers brings the lap forward, when any average variation in the thickness for the full width of the lap is recorded on the diagram by the mechanism shown on the right-hand side of the machine. Each top regulating roller is fixed in a cradle, and each cradle is connected by a flexible wire or chain to the adjacent one through the medium of a pulley mounted on a lever. The mechanical combination and connection of all these pulleys to the main lever is a modification of the principle of what is known as the "piano feed," in which the vertical movement of any of the top regulating rollers, or the sum total of several of them, is transferred to the diagram as already stated. So as to obtain a diagram which records very small differences of average thickness of the lap, the actual thickness is multiplied eighty times.

Just as the engineer obtains the highest efficiency from his engine by setting the valves, etc., according to the indications of his steam diagram, so will the carder obtain more perfect laps for his cards when he adjusts his Scutcher regulators and fan draughts so that the resultant diagrammatic line approaches nearer to absolute straightness as recorded by the lap tester.

An analysis of a record traced by the new machine is interesting and instructive. By its aid otherwise unsuspected variations in the thickness of the lap (sometimes exceeding 30 per cent.) may be definitely located either to defective cage action (fan draughts) or to some irregularity in the feeder mechanism. A lap is preliminarily tested, and if the indica-

tions, for example, show that air currents are responsible for fluctuations, the air displacement is altered, or "back" draughts remedied. Another lap is then formed, tested, and compared with the former. By this means the carder has a positive indication of improvement, and therefore no longer dependent on conjectural experiments.

Not only is a uniform thickness of lap the foundation of superior yarn, but by improving the working conditions of the intermediate processes to the spinning machines, it increases the production, reduces the waste, and alleviates the work of the operatives with corresponding satisfaction to all concerned.

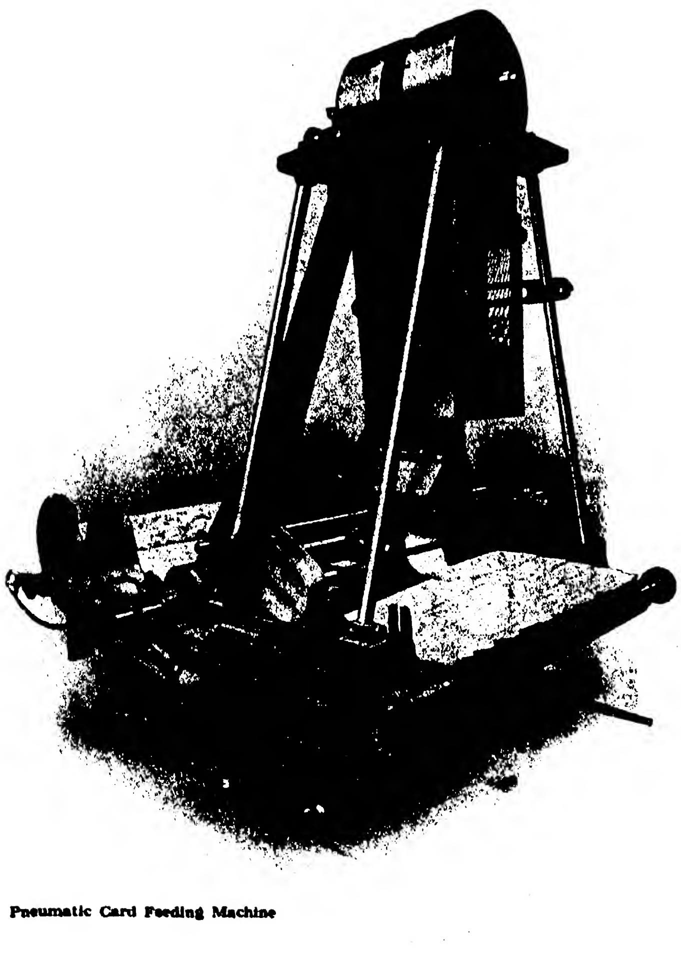
Pneumatic Card Feeding Machine

For the production of waste yarns the intermediate processes of drawing and roving are omitted, but to attain some degree of regularity four methods of feeding the finisher card are generally employed, viz. :

(1) Drum sheet feed ;
(2) Derby doubler feed ;
(3) "Scotch" feed and its modification ; and
(4) Blamires feed.

A new arrangement of feed, to replace any of the above combinations, simply consists of feeding two scutcher laps to a taker-in and depositing the opened mass, by means of a current of air, on to the finisher card lattice in the well-known "Scotch feed" manner.

The taker-in is of the lagged variety, revolving at a higher velocity than the usual practice and in combination with a humbug roller of fine teeth. This action avoids nepping or weakening the stock. On the other hand, the heavier impurities are expelled, and the fibres efficiently separated to the most suitable condition for delivery to the fan. This fan is the essence of the invention, since it thoroughly opens and mixes the waste. Passing through the fan, the waste is then impelled down an oscillating trunk to two calender rollers carried in a carriage which traverses to and fro across the finisher card lattice in the Scotch feed method. At this point the accumulated fleece is laid on the lattice in a narrow ribbon of hitherto incomparable softness.



Pneumatic Card Feeding Machine

As a waste mixing comprises fibres which have previously undergone rough manipulation, it is evident that by eliminating all the carding functions of the breaking machine (with the exception of the taker-in), the further weakening is avoided. Stripping, grinding, various readjustments and expensive renewals of card filleting, etc., are no longer necessary, and a considerable economy in production, expenditure, power, labour and space is realised.

The use of air currents enables a given bulk of cotton fed in a given time to be delivered in reduced bulk, but at a proportionally greater velocity and length. By this means the number of zigzag layers in superposition on the finisher card lattice may be increased considerably without affecting the hank feed, thus producing yarns of superior regularity. In other words, an additional draft and corresponding doubling is introduced, which, in the Stott's system, and impossible on others, is achieved by accelerating the rate of carriage traverse. If 3 double layers per foot of traverse are increased to 6 for the same area of lattice, it is obvious that each layer will now be one-half the original thickness; and that the change is tantamount to doubling 2 ends with 2 of a draft; consequently the resultant feed to the finisher card will contain double the regularity.

The feed rollers in this system are rotated by positive gearing driven from the doffer of the finisher card ; the bulk and rate of feed is therefore always synchronous with the condenser delivery, and not affected by a slipping driving belt, which otherwise would vary the regularity of the finished yarn.

A second fan is applied to exhaust the air from the cages in the traversing carriage. The action, therefore, at this position, is identical to the scutcher machine, but more efficient, since a smaller bulk of cotton is treated at a greater velocity. By this means there is no "crowding" on the cages, with the assurance that every particle undergoes the influence of the air suction, when any remaining dust and loose impurities are removed. The latter is either mechanically condensed into fleece form and delivered to a special receptacle,

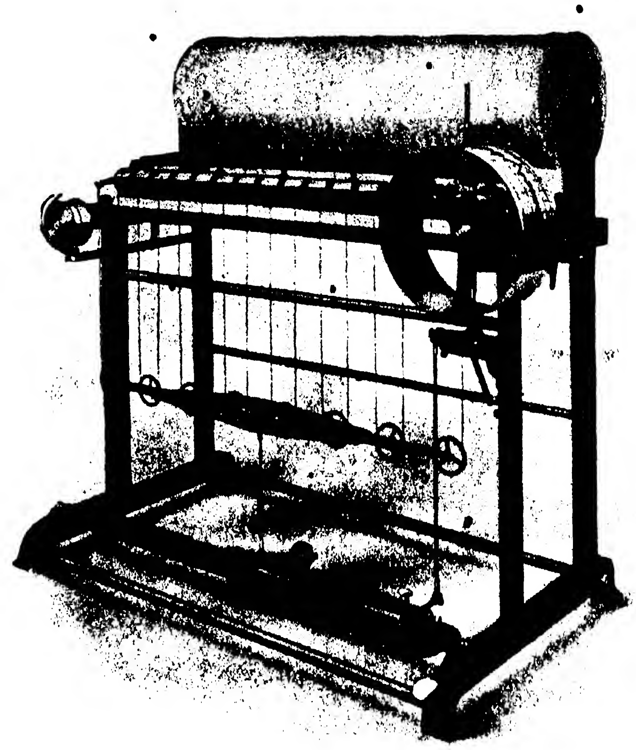
or simply exhausted into the dust chamber.

Finally, when it is considered that the cotton, for the whole width of the lap as absorbed by the feed rollers, is concentrated at the fan, it follows that perfect mixing is the outcome.

From these particulars it is therefore evident that the new installation ensures :—

(1) Less waste.
(2) Fibres finally delivered in stronger condition.
(3) Fibres more perfectly separated (unmatted).
(4) More doublings on the finisher card lattice.
(5) Synchronous movement of the feed and condenser delivery ; and
(6) Efficient blending of the fibres with a corresponding uniformity of colour.

The following tests, which were taken under ordinary working conditions, are of interest, and conclusively confirm the above advantages, viz., that a stronger and more regular yarn, of uniform colour and elasticity, with greater production and less waste and cost, is achieved :—



Lap Testing Machine

FIRST TEST (2's YARNS).

Comparison between the Ordinary System (A) and Patent Pneumatic Card Feed (B).

PROCESS A.

Two laps "bump" up on finisher condenser card ; thence rovings spun into 2's on a roving frame.

7 tests from A resulted in an *average* of 2.2's counts breaking at 95 lb. (60 yards).

Variation in counts of A = 24 per cent. ; variation in strength in lbs. = 26 per cent.

PROCESS B.

Two laps "bump" up on P.C.F. connected to finisher condenser card ; from thence rovings spun into 2's on a roving frame.

7 tests from B resulted in an *average* of 2.06's counts breaking at 146 lb. (60 yards).

Variation in counts of B = $1\frac{1}{2}$ per cent. ; variation in strength in lbs. = 26 per cent.

Counts and breaking strain efficiency

$$\begin{pmatrix} A = 209 \\ B = 300.7 \end{pmatrix}$$

Equivalent to 43 per cent. in favour of pneumatic card feed.

The condenser bobbins from B process contained 22 per cent. more rove than from A for the same diameters.

SECOND TEST (12's RINGS TWIST).

Comparison between the Ordinary System (A) and Patent Pneumatic Card Feed (B).

PROCESS A.

Two laps "white" up on breaker card—Derby doubler—finisher card—speed frame—ring frame.

PROCESS B.

Two laps "white" up on pneumatic card feed—finisher card—speed frame—ring frame.

N.B.—The rovings from B process were so hard that 25 per cent. less twist was inserted on the speed frame as compared to process A.

In A test (normal twist in rovings) the average counts were 11.36 at 67.5 lb. breaking strain.

In B test (25 per cent. less normal twist in rovings) the average counts were 11.11 at 80.9 lb. breaking strain.

Both were spun simultaneously on the same ring frame.

Variation in counts of—

A — 16 per cent.
B — 10 per cent.

Variation in strength of—

A = 36 per cent.
B — 21 per cent.

Counts and breaking strain efficiency

$$\begin{pmatrix} A = 77 \\ B = 90 \end{pmatrix}$$

Equivalent to 17 per cent. in favour of pneumatic card feed.

THIRD TEST ($2\frac{1}{4}$'s YARN).

Comparison between the Ordinary System (A) and Patent Pneumatic Card Feed (B)

PROCESS A.

Two laps inferior "bump" up on finisher condenser card, from thence rovings spun into $2\frac{1}{4}$'s on a roving frame (similar to No. 1 test).

PROCESS B.

Two laps inferior "bump" up on pneumatic card feed connected to finisher condenser card, from thence rovings spun into $2\frac{1}{4}$'s on a roving frame (similar to No. 1 test).

Two tests were made, viz. :—

(1) Yarn with normal twist ($4\frac{1}{4}$ turns per inch) and
(2) Yarn with 25 per cent. less (3.4 turns per inch)

A—With 3.4 turns per in. the average counts were 2.80 giving 10 lb. breaking strain.

B—With 3.4 turns per in. the average counts were 2.16 giving 40 lb. breaking strain.

A—With $4\frac{1}{4}$ turns per in. the average counts were 2.38 giving 60 lb. breaking strain.

B—With $4\frac{1}{4}$ turns per in. the average counts were 2.14 giving 75 lb. breaking strain.

As compared to A test the waste in B test was 13 per cent. less, and the condenser bobbins contained $16\frac{1}{2}$ per cent. more rove for identical diameter when full.

Counts and breaking strain efficiency (3.4 twist) :

$$\begin{pmatrix} A = 28 \\ B = 86 \end{pmatrix}$$

Counts and breaking strain efficiency ($4\frac{1}{4}$ twist) :

$$\begin{pmatrix} A = 142 \\ B = 160 \end{pmatrix}$$

Equivalent to 200 per cent. in favour of the pneumatic card feed with 3.4 turns per inch.

Equivalent to 13 per cent. in favour of the pneumatic card feed with $4\frac{1}{4}$ turns per inch.

Low Temperature Carbonisation (x)

(THE POWER GAS CORPORATION PROCESS)

By DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min.E., Mem. Am. Soc. M.E., A.I.Mech.E., etc.

THE "Power Gas Corporation" process is the invention of Mr. W. Beswick and Mr. N. E. Rambush, and is handled by Messrs. The Power Gas Corporation Ltd., Parkfield Works, Stockton-on-Tees. The information contained in this article is obtained mainly from the paper, "Improved Low Temperature By-product Recovery Gas Producer Process," read by the Power Gas Corporation Ltd., at the Conference on Low Temperature Carbonisation, held at Cardiff on the 20th April, 1922, under the auspices of the South Wales Institute of Engineers, and the important paper, "Production of By-product Producer Gas under Low Temperature Conditions," read by Mr. N. E. Rambush on November 3rd last, before the West of Scotland Iron and Steel Institute in Glasgow, but the writer has also to thank Mr. Rambush for personal information in addition.

As is well-known, Messrs. The Power Gas Corporation Ltd. own the "Mond" gas patents, and they have for the last thirty years supplied and erected "Mond" gas plants according to the original patents of the late Dr. Mond, and latterly those of Lymn.

The new "Beswick-Rambush" process, which has just been perfected after four years' continuous research and large scale experimental work of a most expensive character, is in reality a very much improved "Mond" gas process, in which the latter is combined with low temperature carbonisation for the recovery of the oils.

The original "Mond" gas process consisted essentially of a producer utilising bituminous coal, generally cheap slack, in which a very large amount of steam was used, 2½ tons per 1 ton of coal, of which, however, the equivalent of about ¾ ton was recovered, the nett amount being 1¾ tons, only about 30 per cent. of this large amount being decomposed in the producer. The yield from 1 ton of average coal (slack) was, say, 135,000 cubic feet of gas, 140 B.Th.U. nett per cubic foot, leaving the producer at 1,065 deg. F. (575 deg. C.), and a very high yield of sulphate of ammonia, about 85-95 lb. per ton, corresponding to about 60 to 70 per cent. of the total nitrogen in the coal, which averages, say, 1.4 per cent. The gas, of course, was used for heating and for power in large gas engines, whilst the yield of tar from English coals was about 6 to 10 gallons, of poor quality, containing a large amount of pitch, and little or no value. For many years the "Mond" gas process was most successful in providing cheap heat and power, and a large number of plants were erected. The war, however, changed the whole situation. The price of coal and of sulphuric acid advanced in an extraordinary manner, far out of all proportion to the advance in the price of ammonium sulphate, from the sale of which the profits of the process largely depended. Also, the costs of labour rose rapidly, together with the initial capital outlay on the plant, whilst during the last few years, also, the increasing competition from synthetic ammonia has kept down the price of sulphate of ammonia. Consequently, the ordinary "Mond" gas process ceased to pay, and finally nearly all the plants in the country closed down or were worked without ammonia recovery. In seeking to improve the process, Messrs. Beswick and Rambush concentrated on improving the yield and quality of the tar oils, whilst retaining the high gas and sulphate of ammonia yields, and the method they eventually evolved consists essentially in keeping down the temperature in the top part of the producer, so that the coal charge, in travelling downwards, is only subjected at this stage to a low temperature carbonisation, and the oils given off are essentially "low temperature," both in quantity and quality. In order to maintain the latter conditions, the temperature in the top half of the producer must not be allowed to exceed 570-750 deg. F. (300-400 deg. C.), since oil and gaseous products begin to be evolved at this temperature, and the low temperature decomposition is complete at, say 930 deg. F. (500 deg. C.). In the ordinary "Mond" producer, however, in which the gas is delivered in a hot, crude state, the temperature to which the coal is subjected, as soon as it enters the top of the producer, is at least 1,020 deg. F. (550 deg. C.) average, and often exceeds this figure. Consequently the coal, before it is completely gasified in the lower part of the producer, is in reality subjected to a short high temperature carbonisation from the heat of the bottom part of the producer, and the hot gaseous and volatile products rising up through it. This means that the valuable low temperature oils and other liquid products first evolved are "cracked" and decomposed into a further amount of gas, a smaller quantity of other and more complicated liquid compounds and free carbon (soot).

In designing a "Mond" producer, therefore, in which the coal in the top half is not subjected to a temperature from the lower half exceeding 570-750 deg. F. (300-400 deg. C.), with separation of the low temperature oils, two general methods can be adopted:—

(1) By placing in the upper part of the producer a separate chamber in which the coal is first carbonised for several hours whilst under mechanical agitation, and only using for the purpose of carbonising part of

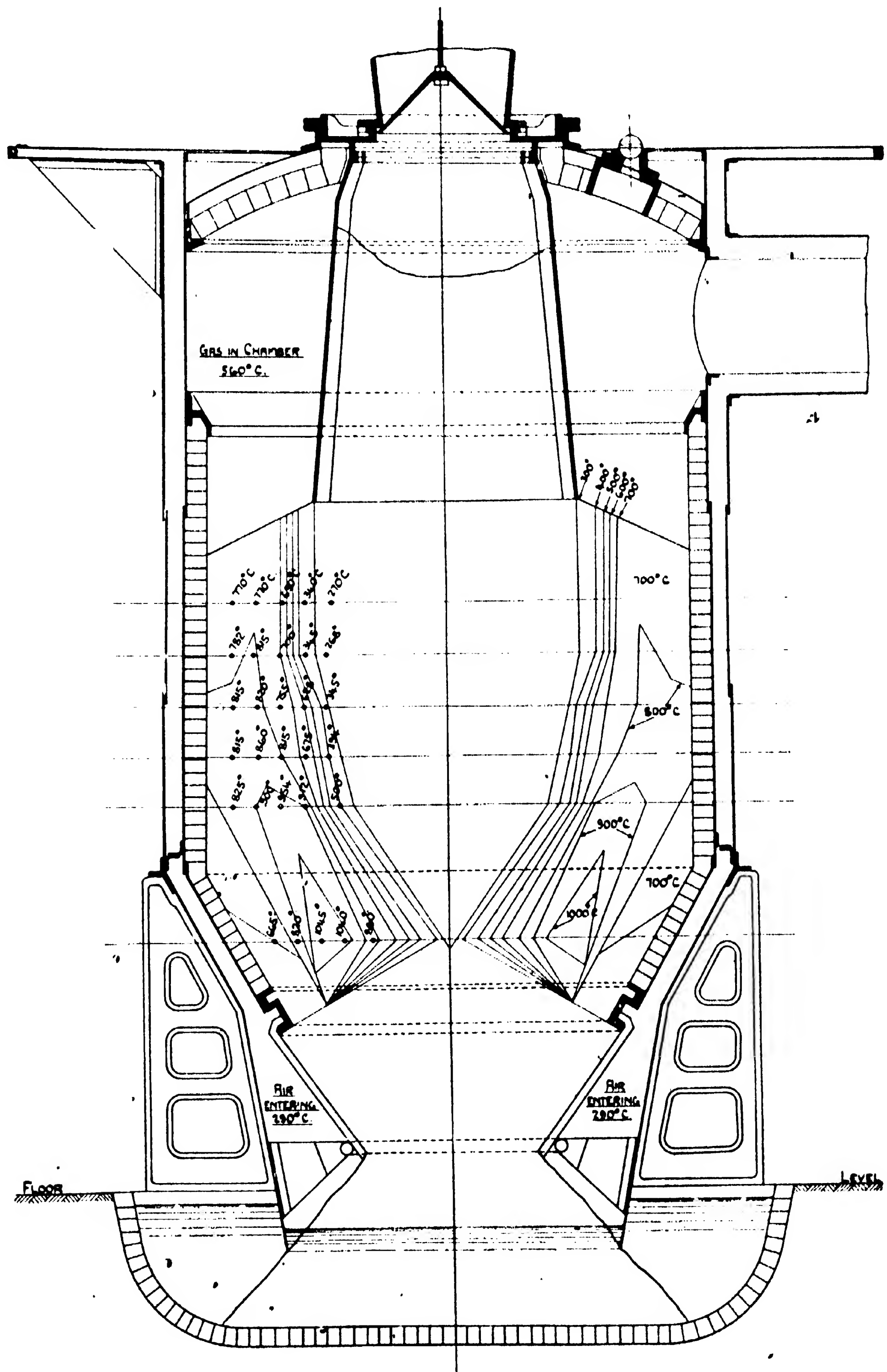


Fig. 1. Showing Temperature Variations in Old Mond Producer

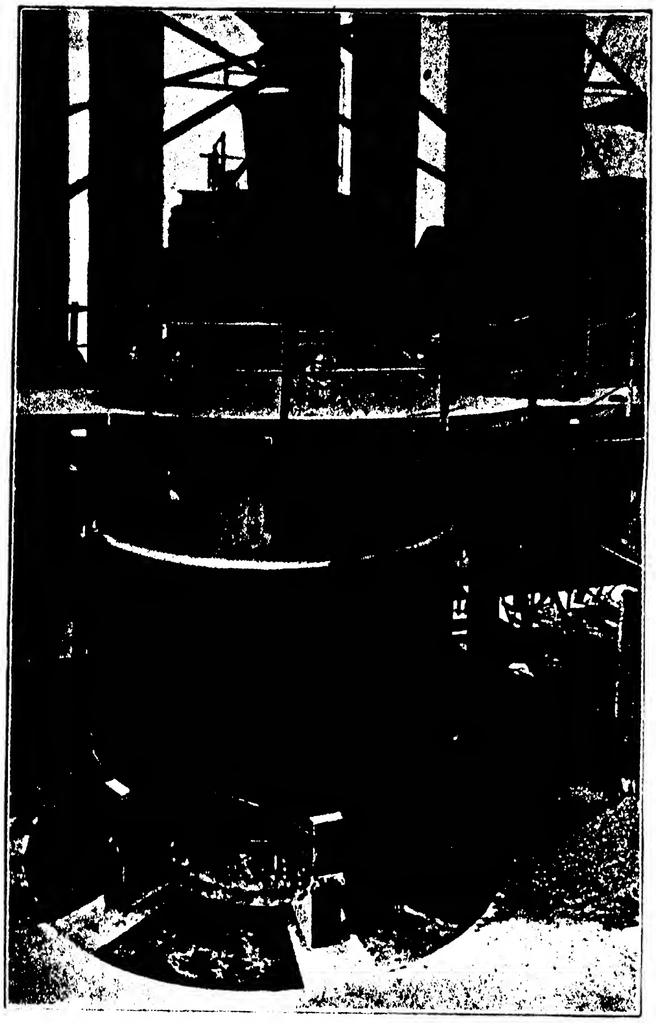


Fig. 4. Reconstructed Old Mond Producer

the hot gases evolved in the lower zone, the producer gas evolved being kept separate from the rich gas evolved in the top half by the carbonisation of the coal in the chamber.

(2) By making the fuel bed much deeper than usual, but only of the usual width, so that the whole of the charge is slowly gasified and low temperature carbonisation in the upper portion carried out because of the much greater mass keeping down the temperature, since only the same amount of total gasification as before is being carried out in the bottom zone.

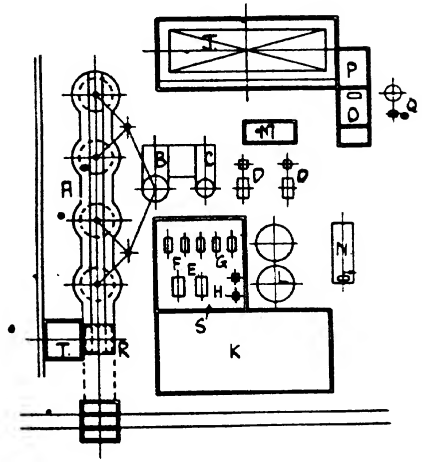
The "Power Gas Corporation" process is on the second principle, and two types of special low temperature producers have been perfected to replace the ordinary "Mond" gas producer, one of which is termed the "low temperature producer" and the other the "semi-low temperature producer," depending on the final exit temperature of the producer gas as it passes through the coal in the top of the producer. It was soon found, however, in practice that other factors besides mere reduction in temperature enter into the problem. Thus it is very important that the temperature to which each particle of coal is subjected must be even right across the sectional area of the producer.

Fig. 1 gives an interesting and valuable diagrammatic illustration of an ordinary "Mond" gas producer, showing the differences in temperature of the various layers when the producer is worked at its rated capacity with maximum ammonia recovery. Although the average temperature at the top exceeds 1,020 deg. F. (550 deg. C.), the fuel particles in a horizontal plane through the top layer at the edges vary from 570-1,290 deg. F. (300-700 deg. C.), so that the entering fuel nearest the wall of the producer is submitted to a very much greater temperature than in the middle, and this is probably just as much the cause of about 50 per cent. of the tar oils being cracked at the average temperature of, say, 1,065 deg. F. (575 deg. C.). Also, it is necessary to have a definite time lag to allow the gradual decomposition of the volatile matter to low temperature oils without cracking, the rate of evolution being of the greatest importance. In the ordinary "Mond" producer this time lag is practically nil, the raw coal entering at once into a temperature zone of over 1,020 deg. F. (550 deg. C.).

Taking, now, the two new plants designed to embody these ideas :—

(1) Semi-Low Temperature Plant.

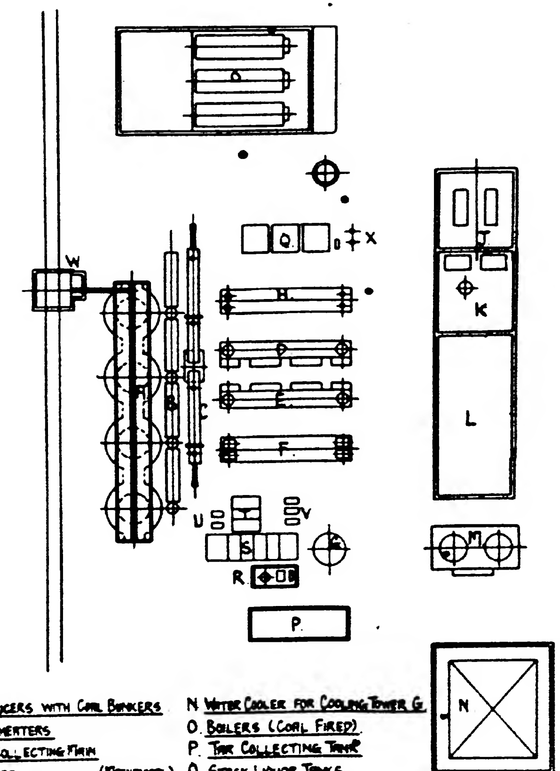
This type has been designed chiefly to be applied to the existing "Mond" gas plants that are shut down, and at present four such large plants are being adapted. Figs. 2 and 3 show the sectional elevation of the old "Mond" gas producer, and of the new semi-low temperature producer plant. In the new plant the charge is increased very considerably by extending the height and modifying the shape at the top; whilst the central feeding bell of the old "Mond" plant is substituted by a new circumferential fuel feed. This latter is designed on the principle of extending the mouth of the gas outlet pipe to under the surface of the freshly-charged fuel which fills the producer right to the top. This arrangement also ensures that all the gas must pass through the centre of the top of the fuel bed, and heats the middle portion of the charge as well as the edges. In practice the temperature in the coal across the top of the charge is very even, and varies with the output from 480-840 deg. F. (250-450 deg. C.), whilst the time lag is ½-1 hour, with a gas outlet of 660 deg. F. (350 deg. C.), instead of almost instantaneous as in the ordinary "Mond" plant. Fig. 4 is a photograph of a semi-low temperature plant built up from an old "Mond" gas



A. Producers.
B. Ammonia Absorber with Settling Tank
C. Cooling Tower . . .
D. Centrifugal Cleaners
E. Air Blowers.
F. Sulphate Liquor Pumps for B
G. Water Pumps for C & J
H. Sulphate Liquor Pumps for S
J. Water Cooler for C
K. Sulphate Store.

L. Stock Liquor Tanks
M. Tar Settling Tank for D
N. Boiler (Gas Fired)
O. Tar Pump
P. Tar Collecting Tank
Q. Tar Dehydrating Plant
R. Coal Hoist
S. Sulphate Evaporating Plant above Machinery House
T. Ash Bunker

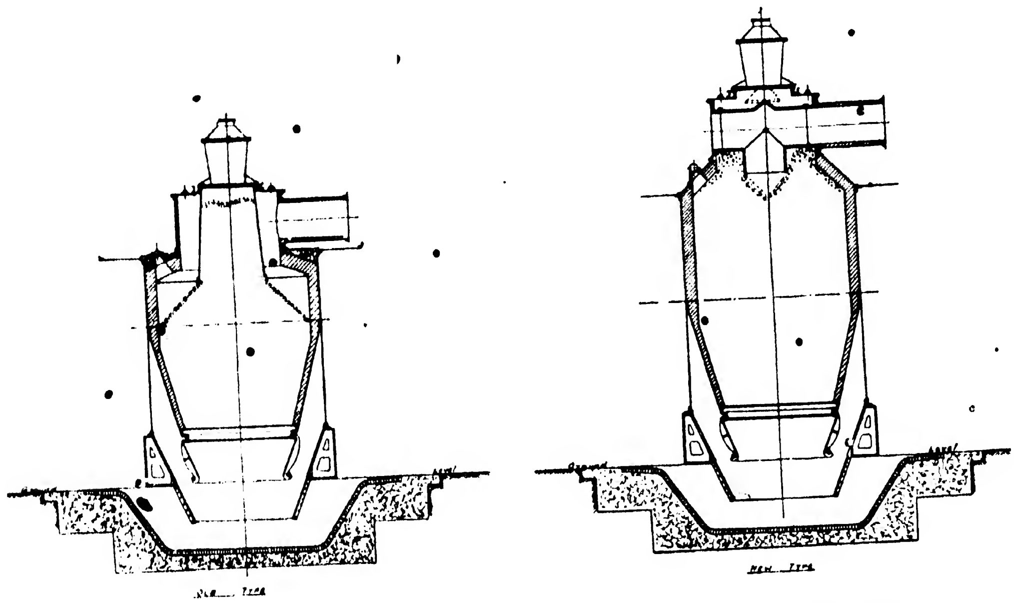
Diagram of
L.T. Bye-Product
Producer Gas Plant
Capacity 100 Tons of Coal per 24 hours
Scale 1/400"



A. Producers with Coal Bunkers
B. Superheaters
C. Gas Collecting Main
D. Washer (Mechanical)
E. Ammonia Absorber (")
F. Cooler (")
G. Cooling Tower
H. Air Saturator (Mechanical)
J. Air Blowers
K. Sulphate Evaporating Plant
L. Sulphate Store
M. Tar Dehydrating Plant

N. Water Cooler for Cooling Tower G
O. Boilers (Coal Fired)
P. Tar Collecting Tank
Q. Stock Liquor Tanks
R. Tar Pump etc.
S. Settling Tank for Cooling Tower G
T. Water Circulating Tanks for F & H
U. " " Pumps " "
V. " " " " G-N
W. Coal Elevator
X. Liquor Eggs for K

Diagram of
"Mond" Bye-Product
Producer Gas Plant
Capacity 100 Tons of Coal per 24 Hrs
Scale 1/200"



COMPARATIVE DIAGRAM OF OLD & NEW TYPE BYE-PRODUCT GAS PRODUCERS

Figs 2 and 3

plant at the works of the South Staffordshire Mond Gas Plant at Tipton, Staffs, which has been working with great success since the beginning of 1922. The exact results of a 168-hour test are as follows:

TEST ON SEMI-LOW TEMPERATURE PLANT

Load on producer 25 tons of coal per 24 hours.
Calorific value of fuel—11,577 B.Th.U.
Size of coal 55 per cent. above $\frac{1}{2}$ in., 27 per cent. $\frac{1}{2}$ to $\frac{1}{4}$ in., 10 per cent. $\frac{1}{4}$ to $\frac{1}{8}$ in., and 8 per cent. below $\frac{1}{8}$ in.
Maximum gas output—297,000 cubic feet (N.T.P.) per hour.
Minimum gas output 44,100 cubic feet (N.T.P.) per hour.
Temperature of air blast 176 deg. F. (81 deg. C.).
Temperature of exit gases—660 deg. F. (350 deg. C.).
Lbs. of steam used per lb. of coal gasified—1.33.
Thermal efficiency of plant 76 per cent.
Percentage of carbon in ash 15.6 per cent.

YIELD PER TON OF DRY COAL

(1) Gas (N.T.P.), cubic feet—122,400 at 160.3 B.Th.U.

Composition of gas:—

CO_2	12.2 per cent.
CO	12.7 „
H_2	27.8 „
CH_4	3.8 „
Nitrogen ...	40.5 „

(2) Low temperature oils (dry)—19.0 gallons.

(3) Sulphate of ammonia—99 lb.*

*This corresponds to 60.7 per cent. of nitrogen recovered, the figure for the dry coal being 1.5 per cent.

The advantages claimed for this semi-low temperature plant, in comparison with the old "Mond" gas plant, are 50 per cent. higher daily gasification, a heating value of 160 B.Th.U. instead of 140, carbon in the ash 15 per cent. instead of 30 per cent., ammonia yield same, less than half the steam consumption, a particularly important point, increase of tar yield 30-40 per cent., thermal efficiency improved by 10 per cent., and no superheating of air blast necessary.

(2) Low Temperature Plant.

This is on the same general lines, but is intended for new plants, the time factor is longer and the temperature still lower, so that the volatile matter is evolved more slowly, being 3-4 hours, with an exit gas temperature of about 380 deg. F. (200 deg. C.), whilst there is an almost entire absence of cracking. A plant was erected at Stockton-on-Tees at the end of 1921, with a 5 ft. internal diameter producer, and has been working ever since with great success.

The results of a typical four days' run (November, 1921) are given below:—

	1/11/21	2/11/21	3/11/21	4/11/21
Coal consumed per hour (tons)	7.40	5.60	5.75	5.00
Air blast temperature ...	165 deg. F. (75 deg. C.)	165 deg. F. (75 deg. C.)	165 deg. F. (75 deg. C.)	165 deg. F. (75 deg. C.)
Amount of steam decomposed ...	70.0%	83.7%	88.0%	83.4%
Yield per Ton of Coal—				
(1) Gas. Not measured accurately.				
Analysis of gas—				
CO_2	7.0	7.0	8.0	8.4
CO	21.5	22.0	21.0	20.0
H_2	20.0	19.0	21.0	21.0
CH_4	5.7	5.4	5.4	5.1
N_2	45.8	46.6	44.6	45.6
Nett calorific value ...	185.8	182.0	184.3	178.0
(2) Sulphate of ammonia by analysis (ccs. of N acid per cub. m.)	182	171	226	230
(3) Tar oil, by analysis (grammes per cub. m.)	19.5	23.1	27.8	39.5

Another test carried out had a consumption of 5.25 tons of coal per 24 hours, corresponding to 26.1 lb. of coal per square foot, the steam used being 0.94 lb. per lb. of coal, whilst the air blast temperature was 165 deg. F. (75 deg. C.), and the exit gas temperature below 390 deg. F. (200 deg. C.). The full analysis of the dry coal used was, carbon 73.6 per cent., hydrogen 5.3 per cent., oxygen 14.0 per cent., nitrogen 1.56 per cent., with 8.1 per cent. ash, the volatile matter being 36.2 per cent., and the nett calorific value 12,200 B.Th.U. The yield per ton of dry coal was :-

(1) Gas, 120,000 cubic feet, 178 B.Th.U., the analysis being :

CO_2 ...	... 8.3	per cent.
CO ...	... 21.0	,,
H ...	... 20.5	,,
CH_4 ...	... 4.9	,,
N_2 ...	... 45.3	,,

(2) Tar oils, 20 gallons.

(3) Sulphate of ammonia, 90 lb. (56 per cent. efficiency).

The gasification efficiency was 91½ per cent., including tar, and 78.4 per cent. excluding.

Mr. Rambush gives the essential figures for the difference between the old "Mond" gas process, the new semi-low temperature process, and the new low temperature process, as follows :-Taking in each case a typical coal of 12,000 B.Th.U. and 37.0 per cent. volatile, with 12.0 per cent. ash and 1.4 per cent. nitrogen.

A consideration of these figures, taking the low temperature plant as being of more interest from the point of view of these articles, is that the gas volume is slightly reduced, say from 134,000 to 118,000 cubic feet. The gas is, however, of a much more valuable quality, being 180 B.Th.U. instead of 135, which is itself a factor of great importance. This is due in the first place to the use of much less steam in the process, but probably also because of the low temperature carbonisation, and one of the results obtained by Messrs. Beswick and Rambush in their investigations is to show that as the exit temperature of the producer gas is lowered from, say, 1,085 deg. F. (575 deg. C.) to 390 deg. F. (200 deg. C.), the heating value of the gas rises from 135 B.Th.U. to 180 B.Th.U. This means, for example, that the new "Mond" gas can now be used in the firing of steel furnaces just as well as ordinary producer gas. The old "Mond" gas was not a success for this purpose, as the quality was too low to maintain the temperature, and the gas consumption was increased by 25-30 per cent. on an equal heating basis. The new "Mond" gas is, however, better than the producer gas now used, since the theoretical flame temperature is about the same, 3,220 deg. F. (1,775 deg. C.), and the quality is better, average producer gas being, say, 163 B.Th.U., with 28 per cent. CO, 4½ per cent. CO_2, 13 per cent. hydrogen, and 3 per cent. methane.

YIELDS PER TON OF DRY COAL.

	Ordinary "Mond" gas process	New semi low temperature process	New low temperature process
Total nett steam required (tons) ...	1.90	1.26	1.05
(a) Steam for blast	1.75	1.10	0.90
(b) Steam for sulphate evap. ...	0.15	0.16	0.15
Coal for steam raising (7 lb. water per 1 lb. of coal) without burning tar ...	0.272	0.180	0.150
Yield of gas, cubic feet	133,500	133,000	118,000
Nett cal. value of gas, B.Th.U. ...	135.9	153.7	182.3
Theoretical flame temperature ...	2,890 deg. F (1,588 deg. C.)	3,085 deg. F (1,697 deg. C.)	3,220 deg. F. (1,775 deg. C.)
Gas analysis			
CO_2	16.0	11.0	8.3
CO	11.0	17.5	20.5
H_2	25.9	21.5	20.5
CH_4	2.7	3.3	5.5
N_2	45.3	46.7	44.9
Yield of tar oils, gallons	10	18½	21
Yield of sulphate of ammonia (lbs.) ...	90	95	90
Efficiency of process			
(a) Gas producer, excluding tar ...	68%	76%	80%
including tar ...	74%	87.2%	92.3%
(b) Overall efficiency, including coal for steam raising, excluding tar	53.5%	64.1%	69.5%
burning tar for steam raising ...	56.7%	72.8%	80.0%

As regards the tar yield, the figure is 20 gallons per ton, equal to the average low temperature process, and the quality is also the same, a remarkable improvement as compared with the old "Mond" process. As Mr. Rambush points out, the quality and quantity is dependent on three factors : (1) quality of the fuel, (2) temperature of the carbonisation, and (3) the rate at which it is driven off. Also, the higher the oxygen content of the coal, the greater the proportion of oxygen compounds in the tar. The ammonia yield is maintained at the same high figure, 90 lb. per ton.

Mr. Rambush points out that when coal is gasified with a mixture of air and steam, the evolution of part of the nitrogen as ammonia probably takes place in two stages, "volatile" ammonia evolved simply by heating, and that formed by chemical reactions between the various gases in the producer and the "fixed" nitrogen in the fuel after the volatile matter has been driven off.

A very interesting opinion is given by Mr. Rambush as the result of these many large scale tests. It is the usual theory that large yields of ammonia in the gasification of coal are due to the use of a large excess of steam, which exerts a protective influence and prevents the decomposition of ammonia as soon as it is formed, so that the old "Mond" process, with 1⅞ tons of undecomposed steam per 1 ton of coal, had the very large yield of 90 lb. Mr. Rambush states that this theory is erroneous, and the same results can be obtained when the quantity of undecomposed steam is about 0.1 tons.

The new process, whether "low temperature" or "semi-low temperature," has a number of other substantial advantages, in addition to improved yields. As regards capital outlay, the plant can be installed to-day at the same price as the old "Mond" plant before the war, and the ground space occupied for the same gas output is only 50 per cent. Fig. 5 is a detailed plan of a low temperature plant and an old "Mond" gas plant, each for a consumption of 100 tons of coal a day, although a large amount of the ground space saved is due to the use of the "Lymn" vertical washers instead of the old horizontal apparatus. Also, because the gas leaves the plant at a lower temperature, the loss of sensible heat is very much less. Thus, in the ordinary hot gas, 1,020 deg. F. (550 deg. C.), plant as used in steel works, the equivalent of 12-15 per

cent. of the coal gasified is used in the process, and in a by-product recovery plant the figure is 16-20 per cent. With the new plant there is a saving of 20-30 per cent. on this figure. Further, the quality of the gas is absolutely uniform, and independent of the charging periods. An ordinary producer, with intermittent charging and an ordinary feed hopper, gives a greatly varying gas. Just after charging, for example, with raw coal, a large part of the volatile matter is driven off almost at once, giving for a short time a rush of rich gas, whereas with a low temperature producer the gas outlet temperature is below that of the volatilising point of the coal, so that the producer can be charged every one to two hours without any difference being noticed in the gas.

Another point is that a low temperature producer, with an extra deep fuel bed, can carry much more easily a big over load, and work with greatly fluctuating demands. Thus detailed figures are given of the performance of a low temperature producer, hand-fired, and with hand ash cleaning, with bituminous slack, in which the pounds of coal gasified per square foot per hour varied from 10.9 to 48.2 lb., and the cubic feet of gas output at N.T.P. per hour varied from 62,000 to 273,000. The demand in one hour was 158,200 cubic feet of gas, and this went up in the next hour to 253,900, and in another period dropped from 171,300, to 75,200 in the next. The normal rating of this producer was 20-22 lb. coal per square foot per hour, and the maximum load was therefore 130 per cent. above normal, and for seven hours continuously was 100 per cent. overload. Finally, the labour is 10-30 per cent. less as compared with the old plant, and it may be noted that low temperature oils are being obtained in a simple plant without any complications.

The New Paris Super-Power Station

(*Continued from page* 434.)

Meux, and sub-stations in place of the old smaller power stations, to which current would be supplied at 60,000 volts and reduced as required. This scheme involved the expenditure of about 250,000,000 francs, and is, in fact, part of the general scheme for the unification of the whole of the power supplies of France. In the future the new super-station will be linked up first with the generating stations in the Pas de Calais, and finally, with the hydro electric power generated on the Rhone, the Rhine, and the Central Highlands.

The new station occupies an area of 120,000 square feet, and the generating plant will consist of 5 turbo-alternators of 40,000 K.W., with room for three more sets, the base of each generator being 56 feet above the bottom of the foundations, which are designed on novel principles of cellular construction. One of these huge turbo-alternators has been supplied by the firm of Messrs. Escher Wyss of Switzerland, two by Messrs. Schneider, and two by the Societe Alscienne de Constructions Mecaniques. The steam pressure is 310 lbs. per square inch, and the turbines have a speed of 1,500 revs. per minute. The boiler house is 283 feet long, and 150 feet wide, and there are two rows of boilers, consisting of 10 "Babcock and Wilcox" boilers in pairs and five "Stirling" boilers. Under the boiler house is a large basement at a height of 33 feet above the foundations, which carries various railway lines for handling ash and clinker, another floor at 46 feet contains the pipes, whilst a third, at 56 feet, on a level with the power house floor, forms the firing floor. The maximum working pressure of the boilers is 350 lbs. per square inch, and the temperature of the superheated steam 375-400 deg.C. (707-752 deg.F.), the evaporation of each "Babcock and Wilcox" boiler being 117,000 lbs. per hour with 14,000 square feet heating surface, whilst the "Stirling" boilers have an evaporation of 176,000 lbs. per hour, and 22,500 square feet heating surface. The whole of the boiler installation is worked with forced and induced draught, and the feedwater from the condensers is heated to 80 deg. C. (176 deg. F., by the turbines, and then to 100 deg.C. (212 deg.F.), by the exhaust from the auxiliaries. It is then degassed and passed through steel tube economisers over the boilers the final temperature entering the boilers, being 160 deg.C. (320 deg.F.). The gases leave the boiler at 340 deg.C. (644 deg.F.), and are reduced to 220 deg.C. (428 deg.F.), in passing through the economisers. A complete installation of air heaters is also fitted, which reduces the final temperature of the exit gases to 150 deg.C. (302 deg.F.), and raising the temperature of the air entering the fires to about 90 deg.C. (194 deg.F.). The economisers have 13,000 square feet surface for each "Stirling" boiler, and 17,000 square feet for each pair of "Babcock and Wilcox" boilers, and some idea of the size of the condensing plant will be made evident by the fact that the condensers have 37,000 square feet cooling surface, and are supplied by two pumps, each capable of a delivery of 6,750 tons of water per hour. The area occupied by the power house is 1.18 square feet per kilowatt, and the area of the boiler house is 2.36 square feet per kilowatt.

THE DEVELOPMENT OF COMMERCIAL AVIATION

That, in the near future, commercial aviation is to be developed on a wide basis, is evidenced by the increasing attention now being paid to the question in nearly every country. In America, in fact, owing to the support given to commercial aviation by the Harding Administration, an Aeronautical Chamber of Commerce of America has been established. Thus, in the States, they are developing along national lines, the objects of the Chamber being "to foster, advance, promulgate and promote" aeronautics, and "generally to do every act and thing which may be necessary and proper for the advancement" of American aviation. In a communication it is stated that commercial aviation can render to the community services described as national. civic and commercial.

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS

Electricity Supply of Leicester

The following interesting particulars have been supplied to us by Messrs. The English Electric Co. Ltd., relating to the new Leicester Power Station, which was opened on December 8th, 1922. The facts recorded in this article give an instructive insight into the growth and development of a modern power station in an industrial town, and also indicate the latest practice under the special local conditions.

Illustrations by courtesy of Messrs. The English Electric Co. Ltd.

THE Corporation first undertook the supply of electrical energy in 1894, when Aylestone Generating Station was erected on the Gas Works site, and supplied single-phase current, principally for lighting purposes. The late Mr. Alfred Colson acted in the dual capacity of Gas and Electric Lighting Engineer, and the controlling body was styled the Gas and Electric Lighting Committee. This Committee continued in charge of the electric lighting department up to the end of the year 1910, when they were relieved of that duty by the Tramways Committee, re-named the Tramways and Electricity Committee.

Previous to this, however, in the year 1904, the Tramways Committee had erected their own generating station at the Lero, for the purpose of giving a direct-current supply to the electric tramway system established in that year. From this station, in the year 1908, the first serious attempt was made, under the direction of Mr. T. R. Smith, to meet electrically the demand for motive power which was rapidly developing in the city. The expedient of connecting power consumers to the 500-volt direct-current mains proved highly successful.

In 1911, the electricity supply to the whole city was placed under the sole management of Mr. Smith, and since that date the growth of the undertaking has been almost phenomenal in character. It soon became necessary to supplement the existing plants both at the single-phase generating station at Aylestone, and at the Lero direct-current station. Three-phase turbo-alternators generating at extra high tension, and representing the most modern practice in electricity supply, were installed from time to time at both works, and a new central sub-station was established in Newark Street for more economically converting and distributing current from the two stations to the ever-increasing number of lighting and power consumers, as well as to the tramways system.

So rapidly, indeed, did the demand for current within the city increase, that the capacity of the two stations became overtaxed, and unequal to the task of adequate supply, while the two sites were incapable of accommodating further plant extensions to deal with the future demands. In 1917, the services of the well-known consulting engineer, Mr. C. H. Wordingham, C.B.E., M.I.C.E., were enlisted, with a view to the preparation of a scheme for extending the electricity supply. Although the conditions attending the war and its conclusion prevented the realisation of the projects then worked out, a number of Mr. Wordingham's recommendations, notably those concerning the site itself, the generating plant, etc., were embodied in the scheme ultimately carried out.

At a later date, the Electricity Committee decided to send their Engineer to America for the purpose of studying the latest practice in the United States, and the result of his visit is shown in many ways in the design of the New Central Generating Station situated on the Freemen's Meadow, Aylestone, and recently opened by the Chairman, Alderman Flint. This station contains the very latest instruments and machinery that the scientific and engineering world has produced, and will be the means of supplying the city and district with energy for manufacturing and domestic usage at rates as favourable as those of any undertaking in the Kingdom.

The progressive policy of the department is evidenced in the new showroom in Market Street. Here all enquiries are met, and apparatus inspected and loaned, and from these head-quarters the Committee are intent upon pursuing an active campaign in the interests of the department and the citizens of Leicester. A special effort is to be made to induce domestic users to utilise heaters and cookers, and the recent reduction in the heating and cooking tariff is a step in the right direction.

In 1901, one and a quarter millions of units were generated, principally for lighting consumers; in 1911, by which time a good power load had been added, as well as the tramways, twelve millions of units were generated, and this had increased to nearly thirty millions in 1921. At the time

of printing, the figures for 1922 were not available, but events point to another substantial increase over the preceding year, the figures at October 31st having reached twenty-nine millions.

The number of lighting consumers on the books of the department at the end of 1922 was nearly 9,000, while factories and mills in the city were being supplied with energy to drive motors developing well over 25,000 horse power.

The present prices for electricity are as follows:

Motive Power

3.6d. to 1.35d. per unit.

Domestic Tariff

(1) A flat rate for lighting, 7d. per unit.

(2) A flat rate for heating and cooking, or alternatively, 1½d. per unit.

(3) A comprehensive charge, including lighting, heating, cooking, and all other purposes: (*a*) a fixed charge of 9/- per lampholder per annum, chargeable on 75 per cent of the total number of lampholders installed, plus (*b*) 1d. per unit.

The New Station

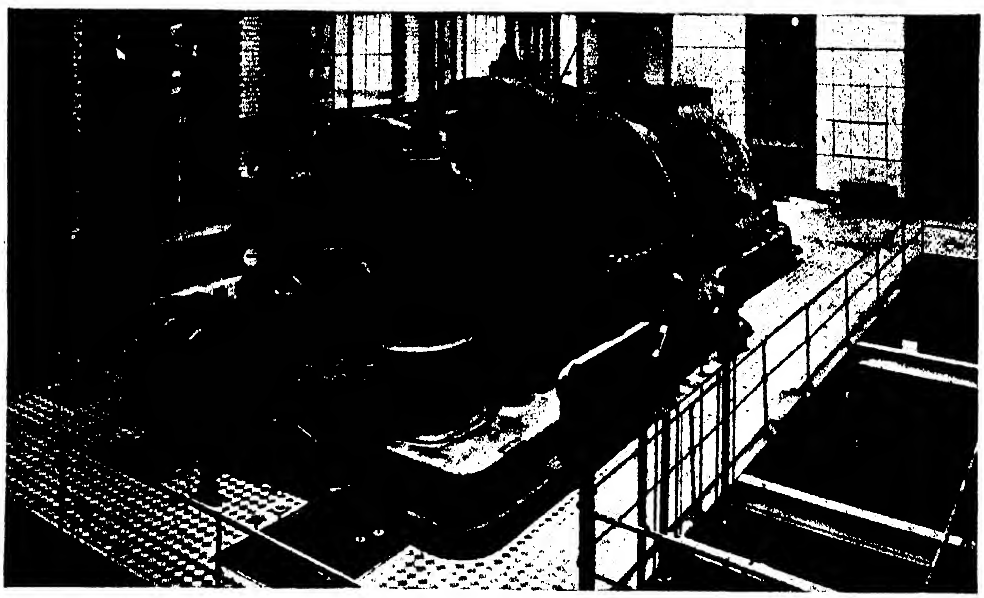
The site of this station is on the right bank of the canalised River Soar, adjacent to the main line of the Midland Railway, and to St. Mary's Road. The situation chosen is very favourable both for delivery of coal by rail or water, and also for the supply and the re-cooling of it for condensing purposes. The ground is well above flood level, and has a subsoil of deep gravel on a bed of shale rock, which forms an admirable foundation for the buildings and heavy plant installed in them.

The main contract was awarded to the English Electric Company Ltd., and included the boiler house, turbine room, switch house, and other buildings, the turbo-alternators, electrical machinery for the auxiliaries, switchgear and extensive civil engineering works. The latter comprised the construction of the railway siding embankment 450 yards long, with extensions to the turbine room and wharf, the extension of St. Mary's Road, and the provision of two 60-inch water intakes, and an open reinforced concrete discharge culvert between the power station and various points on the river.

The boiler house equipment, and the whole of the pipework, were entrusted to Babcock & Wilcox Limited, while the coal and ash-handling plant and wharf construction were placed in the hands of The Mitchell Conveyor and Transporter Company Limited.

The portion of the power station now completed accommodates one 10,000 K.W. turbo-generator unit, with the necessary steam raising and auxiliary plant, but the design of the buildings is such that extensions can be added upon a uniform plan until a total capacity of 65,000 K.W. is attained.

As a result of the careful consideration given to the problem by Mr. Smith, the fullest advantage has been taken of the river for the re-cooling of the circulating water drawn from it. There already existed some 200 yards up-stream from the power house a substantial weir running diagonally across the river for a length of about 500 feet, and the cooling effect due to the water running over this in a thin sheet, as well as that due to the river itself, has been utilised by the following arrangements. A 60-inch diameter intake pipe (No. 1) has been constructed leading from the river bank at the far corner of the site into the screening pit, where there are two circular screens; the water is then pumped through the condenser and out into an open discharge culvert. This culvert runs from the power house along the river bank to a point above the weir, where there exists a larger open expanse of water. The further intake (No. 2) has been constructed approximately half-way be-



10,000 Kilowatt Turbo-Alternator

tween the weir and No. 1 intake, with the object of dealing with the water at flood levels when the difference in level between the two sides of the weir is slight. Under such conditions the circulating water would be drawn in No. 2 intake, and after passing through the condenser, discharge through No. 1 intake, which then becomes the discharge pipe. Suitable valves, etc., are provided in the waterways, so as to facilitate the change over from one method of working to the other.

This scheme is the result of extensive research conducted on the site, which showed conclusively that sufficient cooling effect could be obtained from the flow over the weir to deal with, perhaps, 20,000 K.W. of plant.

The following is a short description of each of the important items of plant in the power house taken in order, from the unloading of the coal to the control of the electrical energy flowing out into the city.

Coal and Ash Handling Plant

In view of the very large quantities of coal and ashes which have to be dealt with in a modern power station, it is necessary to give the greatest attention to all the details in connection with the handling of this material; the work must not only be carried out with a minimum expenditure of labour, but the arrangements must be efficient, reliable, and sufficiently flexible to meet all the conditions which may arise. In the present instance the coal is delivered to the site either by rail along the special siding which has been constructed, or else by river to a new ferro-concrete wharf, 125 feet long by 35 feet wide. Rail-borne coal is unloaded by running each wagon into a "Mitchell tippler," operated by a 10 h.p. motor. This device consists of a cradle which rotates and carries the wagon with it until the latter is tilted at a sufficient angle to discharge its contents into a hopper underneath. The whole operation of tipping and returning the wagon takes less than two minutes. River-borne coal is unloaded by means of a grab-crane into railway trucks, which are then dealt with in the tippler.

From the underground hopper the coal is raised by means of a skip-hoist to the upper part of the boiler house, and there distributed by a belt conveyor into the various bunkers. It should be noted that the coal-handling plant and bunkers are of sufficient capacity to cope with the next set which will be installed at a future date. In due course the coal passes from these bunkers through automatic weighers, and down the chutes to the stoker feeder hoppers on the boilers, the quantity which passes into each separate bunker being automatically recorded.

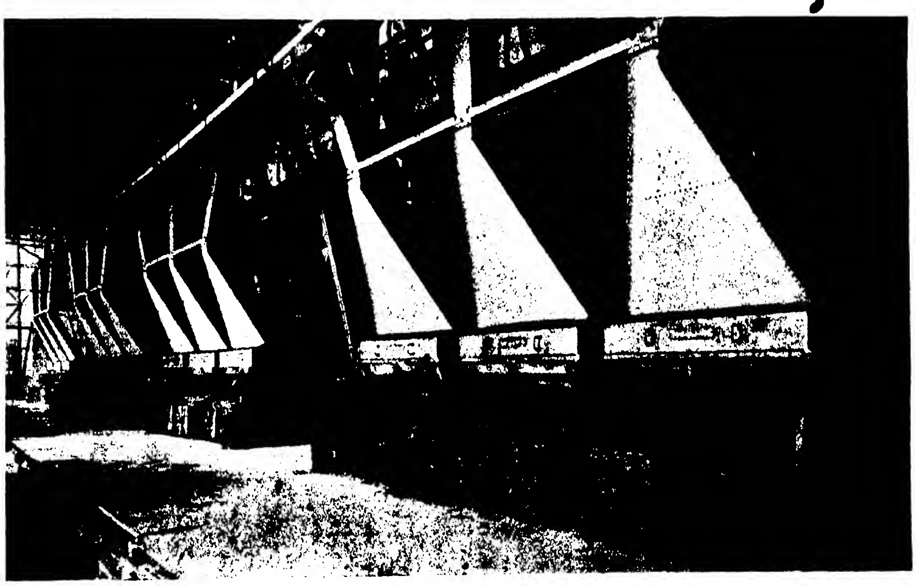
Ash Discharge

The ashes discharged from the boiler grates fall into hoppers which are provided underneath with doors opening into the ash basement. This basement, so called, is, however, at the ground level, so that ash wagons of special design, but of standard railway gauge, can be run underneath the hoppers to receive the ashes, and transport them to the tipping position on the site, by means of a specially-designed steam storage locomotive.

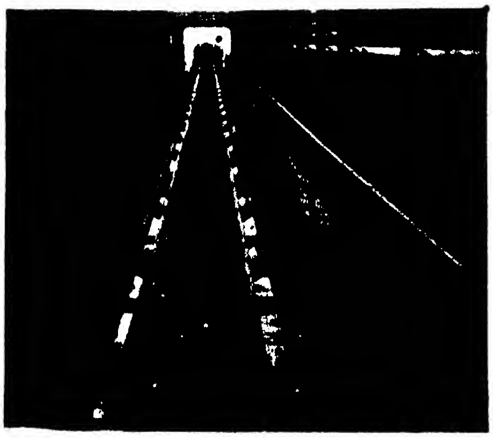
Boiler Plant

The boiler room plant at present installed comprises four boiler units of the Babcock & Wilcox type, each having a steam capacity of 45,000 lbs. per hour. Steam is generated at a pressure of 275 lbs. per square inch, and superheated to a total temperature of 700 deg. F. Each unit is fitted with an integral superheater and superimposed steel tube economiser. The mechanical stokers, of which there are three to each boiler unit, are of the chain grate type, designed to burn low grade coal. The coal is fed from overhead bunkers to the boilers through chutes fitted with control valves, and the quantity used is measured at its entry into the furnaces by suitable meters.

Each boiler unit is fitted with an instrument board, on which are fixed the necessary instruments and appar-



In the Boiler House



Belt Conveyor

Screening Plant

atus to enable the operating staff to obtain at all times the most economical working of the plant.

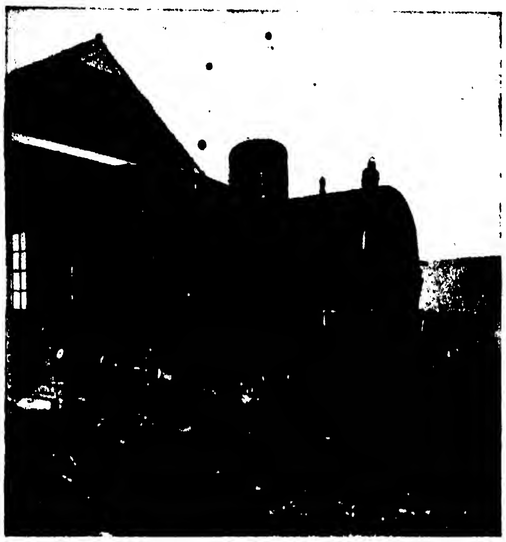
A separate forced-draught fan and the necessary air ducts have been provided for each boiler, so that it can be operated under balanced draught conditions when low grade fuel is to be consumed, or on natural draught when higher grade fuel is used. For this purpose the chimneys are divided into two portions at their lower sections, and fitted with induced draught fans which draw the gases of combustion down one section of the chimney from the economiser outlet, and discharge them upwards through the other portion of the chimney.

Messrs. Babcock & Wilcox have also supplied and fixed the whole of the main steam and auxiliary pipework in the station.

Turbo-Alternator Plant

The generating plant at present installed consists of one 10,000 K.W. impulse turbine, coupled to a 6,600 volt 50-period 3-phase alternator supplied with cooled air from a closed circuit air cooler installed immediately below in the concrete foundations, and is complete with surface condenser, extraction pumps, circulating water pumps, and so on. The steam from the turbines, after being condensed, is passed through pipework arranged on what is known as the "closed feed" system, the primary function of which is to provide the boilers with pure feed water, and thus eliminate as far as possible the scaling of the tubes. The necessity of blowing down the boilers, except at rare intervals, is also avoided, and, at the same time, the feed water is kept as free from air as is reasonably practicable, an important point in reducing the liability of trouble from corrosion.

Alternator End of 10,000 Killowatt Turbo-Alternator



Steam Storage Locomotive

Coal Waggon Tippler

A Prache & Bouillon automatic self-cleaning evaporating plant is provided for supplying distilled water at the rate of three tons per hour for the make-up feed, consisting of an automatic self-cleaning double condenser, pre-heater, thermo-compressor, accessories, and the necessary electrically-driven pumps for delivering the distilled water into either a hotwell tank, or, alternatively, to the storage tank situated in the roof of the building.

The condenser, as well as its auxiliary pumps, was supplied by Messrs. W. H. Allen, Son & Co. Ltd., and contains 6,030 brass tubes each ¾ in. diameter and 15 feet long.

Screening Plant for Circulating Water

Freedom from suspended matter is an essential point in the circulating water, and this is obtained in the present instance by passing it through disc type self-cleaning water screens of the patented design, manufactured by Messrs. F. W. Brackett & Co. Ltd. There are two of these screens, and the whole of the circulating water has to pass through them before entering the suction duct leading to the pumps. The principle on which these screens work is as follows: The rubbish in the circulating water is deposited on the face of the screen, and by the rotation of the latter, is elevated out of the water until it reaches the level of the cleaning jets, where it is thrown off into the rubbish hoppers. Each screen is capable of dealing with two and a half million gallons of water per hour, and is complete with the necessary pumps for producing the jets of water for cleaning above referred to. The capacity of this plant is sufficient for a further 10,000 K.W. generating set when installed.

Switch House

An interesting feature of the station is the arrangement of the oil-break switches and other apparatus necessary for controlling the electrical output. As the maintenance of a reliable electrical supply depends to a very large extent upon this portion of the plant, the utmost care has been given to its lay-out in relation to the rest of the station, and the plan adopted is of the most up-to-date character. The whole of the high-tension switch-gear is contained in a separate building, a short distance from the turbine room, and the oil switches are operated by electrical means from the control room situated in an annexe of, and overlooking, the turbine room. In the switch house itself the E.H.T. switches are arranged in separate cubicles, each provided with a pair of iron doors in the external walls of the building, through which alone access can be obtained.

A subway between the turbine house and the switch house serves to carry the whole of the cables and control wiring, and is of ample size to permit of working or inspection in complete comfort.

Special Ash Waggons

The Use and Advantages of Electric Power in the Factory

By J. F. CROWLEY, D.Sc., B.A., M.I.E.E.

(Continued from page 376.)

All illustrations are by courtesy of The English Electric Co. Ltd.

WE have so far considered the sources of power available to the manufacturer, the principles that should govern its application, and the essential elements of the jute industry from the point of view of the power engineer. We have now to consider the most suitable method of distributing the energy from the prime mover, through the factory, until it finds its application at the shaft of the driven machine. This distribution system may comprise one or many links, and these links may be wholly mechanical, electrical and mechanical, or wholly electrical.

Mechanical Distribution

In the early days of factory driving in Great Britain, it was usual to find a Boulton and Watt engine connected by spur gearing to line shafting, and this, in turn, driving the machines by means of leather belts, the additional shafting being driven by further gears, either plain or bevel. Owing to the irregular character of the drive produced, the power lost in transmission, and to the difficulty of suitably connecting various shafts—frequently at different angles to each other together, this system is almost wholly replaced in modern mills by a rope transmission system from the fly-wheel of the engine. If such a system is carefully thought out in a factory suitably designed, it is probably the best mechanical distribution system for heavy powers. An example of a weaving shed drive, comprising ropes and bevel gears, is given in Fig. 1, where ropes from the fly-wheel of the engine drive the second motion shaft, which, in turn, drives the cross shafts through bevel gears. In general, a prime mover of slow speed and low output is connected to the line shafting by ropes, chains, or belts of fabric or leather, and if of slow speed but high output, by ropes or steel belts. Steel belts have been introduced on the Continent for heavy drives of a moderately slow speed, and appear to have given satisfaction. There has not, so far, been much experience in England with them.

Where the prime mover is of high speed, as in the case of a turbine drive, if electrical transmission is not employed, it is usual to adopt a double-helical self-contained single or double reduction gear connected through a coupling to the turbine shaft for reducing the speed to one more suited to the ordinary transmission system. The slow speed shaft of such a gearing is then connected to the line shafting through ropes, chains, or belts in the ordinary way. In India, where this drive has been adopted to a certain extent, it is not unusual to find the second motion shaft of the geared turbine connected through a flexible coupling to one of the heavier mill shafts, the remaining shafting only being driven through ropes. This system has the advantage of effecting a considerable saving in the power lost in transmission, in the case of the direct coupled shaft, but there is a distinct loss of flexibility, as the turbine has, of necessity, to be lined up to the shaft, with which it has to be coupled, and this generally means placing it in an unsuitable position. The whole of the power also is transmitted through the reduction gear, which is liable to be a source of weakness.

It is not intended to consider closely the merits of the different methods of mechanically distributing power, but the following points may be of interest. Belts, which form one of the earlier methods of drive, have still a definite function, particularly for the transmission of low powers. Indeed, through improvements introduced by manufacturers and others, their position has recently been strengthened. The development, principally on the Continent, of the jockey-pulley drive, has extended the field for belt drives,

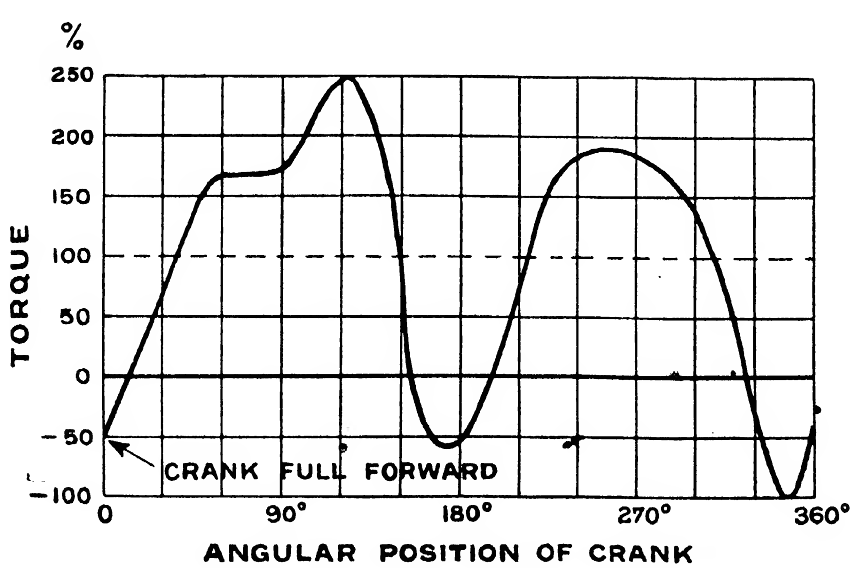


Fig. 2

which are now designed to cope with short belt centres, and exceptionally high pulley ratios.

If due attention is given to lay-out, rope drives should give satisfaction. The minimum diameter of pulley round which the rope has to pass should not be less than thirty diameters if a reasonable rope life is desired. Driving centres also should not be much less than 20 feet for the larger powers, and the angle of drive should not, if possible, exceed 45 degrees with the horizontal. The efficiency of rope drives is not high, but the drive is more flexible, and more steady than can be obtained from gearing.

Chain driving has come to be recognised as a standard method of driving for moderate powers at ratios below 6 or 7 to 1. The drive is positive, being akin to machine cut gearing in this respect. It is, however, flexible in application, needs less aligning to shafting than gearing, and is, in practice, of at least equally high efficiency.

Chain driving is particularly useful where it is found desirable to drive shafts from the centre with a view to keeping cyclic irregularity in speed within proper limits. Electric motors and chain transmission enable this to be done very satisfactorily.

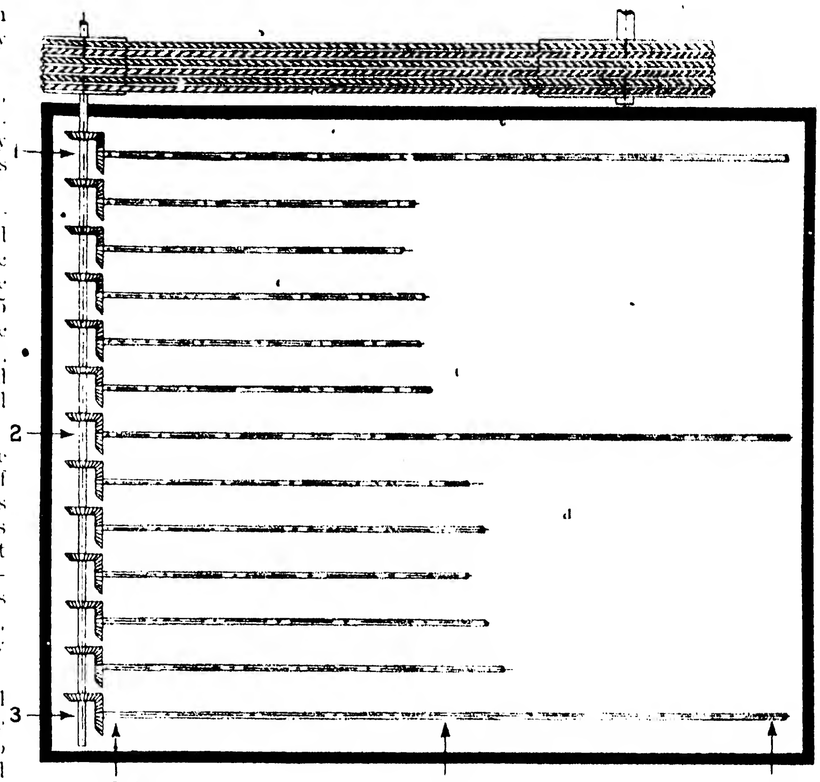


Fig. 1

Electrical Distribution

When electrical distribution is employed, a single large electric motor may be installed to drive the whole of a factory, occupying, then, the position that would, in a mechanical system, be occupied by a turbine, reciprocating engine, or other prime mover. Instead of employing one large motor, a number of small motors can be installed to drive each machine on the principle known as the "individual electric drive." The individual motors may be direct coupled to the machines or drive through a simple transmission link, as, for instance, a belt, chain or gear. Between these two systems lie the various groupings of shafting, which are designated "group electric driving in large units" or "group electric driving in small units," depending on whether the motors are large and drive a number of shafts, or small and driving only small groups of shafts. Just as there is no golden rule as to what transmission system should be employed, so is there no golden rule as to the system of electric driving that should be adopted. Each case has to be carefully considered on its merits, and in the light of experience gained in a similar class of work. Certain guiding considerations can, however, be laid down. In general, the installation of a single large motor, involving as it does the retention of a complicated mechanical power transmission system with its many defects, brings few, if any, of the advantages of electrical driving, and is not to be recommended, nor indeed is the unconsidered adoption of individual electric driving. While undoubtedly the ideal drive, where motors exist, as they now do in almost every case, suited to the work to which it is proposed to set them, individual drive is, in many instances, more costly than group drive. Where this is the case, its application should be confined to machines where it can be shown that its installation has a commercial advantage.

The dividing of the shafting into large or small groups is governed to a certain extent by the desire to reduce the lengths of line shafting, in order to reduce the speed variation or friction losses, and also by the nature of the processes carried on, which, in some cases, require certain departments to be driven independently on account of overtime and of separate power costing.

The principle of providing separately controlled drives for each department is not difficult to apply in a jute factory, particularly in India, where almost all the mills are on the shed principle, and the raw material from the godowns is, as a rule, arranged to enter at one end of the building, and to pass through the successive departments until it reaches the baling-presses as a finished article.

Each department is generally driven by one or more line shafts running parallel to each other across the full width of the building, there being about eight such shafts in a 500 loom mill, and a similar number of shafts, but of much less power, in the weaving shed. In a mechanically-driven mill these shafts are usually connected by ropes running in a rope race to the engine. In arranging for the conversion of this type of mill to electric drive, motors may be placed in the rope alley-way and connected by belts or ropes to each separate shaft.

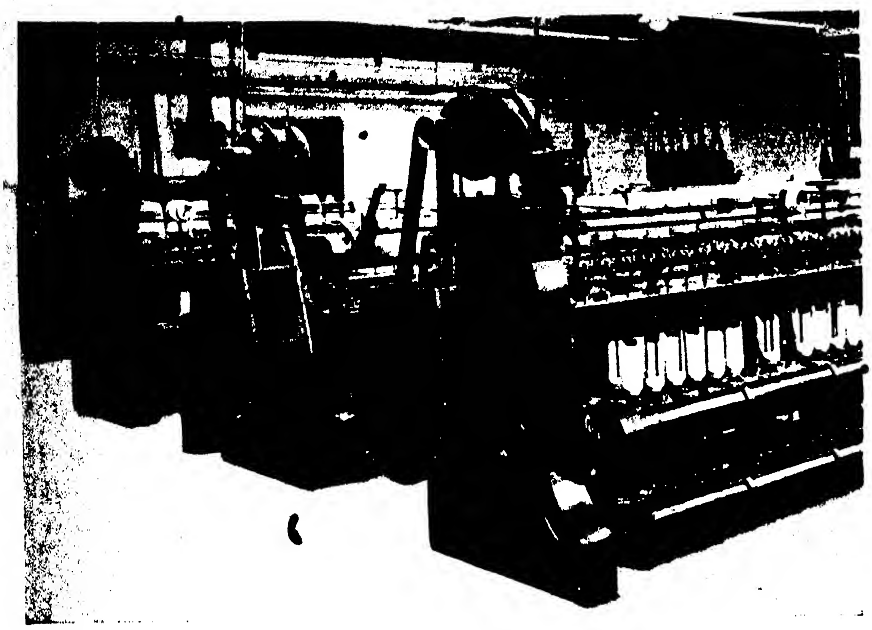


Fig. 3

Weaving shed shafts, which generally run at about 180 r.p.m., are best driven by chain, one motor being placed between two shafts and driving both, or one shaft only.

Electric motors may be placed at the ends of the shafts they have to drive, or in the middle. Placing them in the middle has the important advantage that cyclic variations in speed are very much reduced, but, on the other hand, the overhead view is interfered with, and separate steel platforms have to be provided to carry the motors. There is one important exception to this. The design of many Indian jute mills is such that it is possible and practicable to place motors over the centres of the shafts they have to drive, connecting them to these shafts by chains, the motors themselves being suitably housed in a simple super-structure raised on the flat mill roof. If placed at the ends, the motors are in the clean atmosphere of the alley-way, but the speed irregularity of the shafts may be excessive, particularly if the shafts exceed, say, 300 feet in length, as they do in many Calcutta mills, where at least one shaft 700 feet long is installed. In general, it is desirable to drive weaving shed shafts which are light subject to considerable variations in torque, and require only small powers, from the middle, and the heavier shafts from the end, or if of exceptional length, from both ends. Weaving shed shafts should not, under any circumstances, be run at a speed beyond that which gives approximately a one-to-one pulley ratio. An attempt was made a short time ago to increase the speeds of weaving shed shafts to 368 r.p.m., with results that might have been foretold, when it is remembered that a jute loom requires over twice normal torque at the start, is frequently starting and stopping, and has, besides, a very irregular torque curve. In this case the motors had to be removed, and the shafting reduced to the normal speed. The modern method of driving spinning frames and preparing room shafts is to run them at 485 r.p.m., the softener and end shafts being sometimes run at a slower speed, and couple the motors direct to the shafts through flexible couplings. The shafting can be quite satisfactorily run at this speed, and the pulley ratios for the usual machine speeds are very satisfactory, and a distinct improvement on the ratios in general use in mechanically-driven mills.

If a machine runs intermittently, or requires complicated shafting to drive it, it is probable that it will be desirable to drive it individually. If, too, an exceptionally steady speed is required, as is the case, for instance, with spinning frames and automatic looms, individual drive will almost certainly prove most suitable. It is, further, eminently desirable that all irregularly-running machines, that is, machines which "start" and "stop" frequently, or machines, on the other hand, that have an irregular torque, should not be allowed to interfere with the steady running of other machines on the same line shafting. These should, therefore, be driven by individual motors.

Reference to Fig. 2 will show the serious effect on the power load of a line shaft in a jute mill of the irregular torque of a jute mangle driven from the shaft, and no further illustration should be needed of the importance of removing such irregular running machines from line shafting which has to drive machines that need a steady speed. A similar case would be that of spinning mules in a cotton mill. Here it is clearly desirable that the mules should be separately driven, and not allowed to interfere with the smooth running of other machines. Softeners should be individually driven. They furnish an irregular load, and long line shafting idle for the greater part of its length is required to drive them on the group system. Spinning frames lend themselves admirably to individual drive. An example of a drive suitable for slubbing, roving and spinning frames is given in Fig. 3, the illustration being from an installation put down by the author in an asbestos factory. This, it may be added, is the only illustration given in the paper which is not taken from a jute factory. Direct-coupled motors can be used for spinning frames where the speed of the tin drums can be increased to permit of a motor of standard speed being used. In this case, however, the motor must be of special design, or the drive so arranged as not to give too abrupt a start, which is liable to cause yarn breakage in frames of the "Flyer" type.

For *looms*, the individual electric drive is ideal, and its application for this purpose has been exceptionally rapid. It will be possible to deal with only a few of the leading features of this drive. Fully-enclosed 3-phase motors, capable of giving a high starting torque, with a remarkably high efficiency over a wide range of load, and arranged to be suitable for belt or single reduction gear drive, are employed. In the case of the belt drive, springs are introduced into the motor mounting, so as to give the flexibility needed to deal with shafts which are sometimes out of truth. When gear drive is desirable, as in

the case of low speeds, and for delicate materials, a slipping coupling is introduced, which is so adjusted as not to slip at start, but only on the abnormal overload produced by what is known to the textile manufacturer as a "knock-off."

The most remarkable feature of individual loom drive is the increase in production that results from its use. Through the courtesy of the agents of a large Indian mill -the Wellington Jute Mill, Calcutta, where he installed this drive, the author has received permission to publish comparative tests taken over a period of twelve months between some hundreds of looms running on "hessians" and "sackings," and driven mechanically by a modern reciprocating engine, and a similar number of looms in the same mill, and driven by individual electric motors. The individually-driven "hessian" looms showed an increase in production of 13 per cent., and the "sacking" looms an increase of 8 per cent. over their mechanically-driven neighbours. In the mill engineer's report it is stated that the coal consumption with the steam drive is very considerably in excess of that with the electrical drive, but there is a very considerable saving in regard to labour and oil, and, what is of considerable importance, in mechanical upkeep on the looms, and he concludes: "It is possible to build a loom and drive it electrically, paying for it by the amount saved in running cost, together with the increased production, in a period of from three to four years, or even less, if an exceptionally prosperous season and market favour one."

Individual electric drive should be applied to *dressing machines, damping machines* which run intermittently, to *calenders, mangles,* and *hydraulic pumps* which provide an irregular load, *cropping machines, measuring machines* and *calenderays,* and indeed all machines which do not run continuously, should also be put on single motor drive.

The individual electric driving of calenders, with chain transmission, has proved very successful in practice, and also a similar motor arrangement with gear or worm drive. A small motor is provided for driving the auxiliary shaft.

For driving mangles, laminated belting has proved satisfactory, the motor being of the slipring type, and fitted with a large fly-wheel to enable the peaks of the load curve to be negotiated.

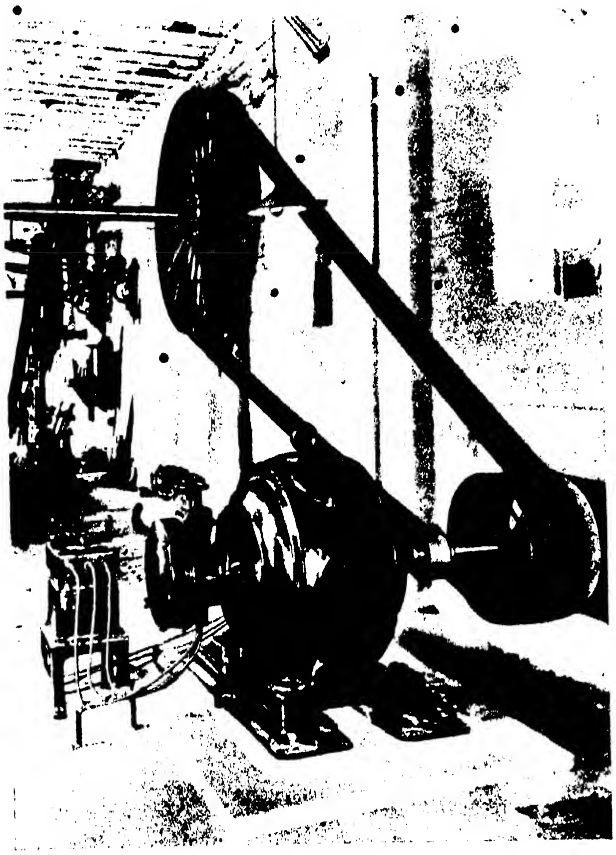
The Advantages of Electric Driving.

Much has been written in favour of electric driving in the factory and the workshop, and it would not serve a useful purpose to go over old ground. There is, however, one outstanding feature of the drive which will probably, from what has been said, stand out in bold relief in most minds, and that is, the increase in productivity of machinery that the proper application of electricity can give. The amount of this increase is dependent naturally on how far the best use has been made in the lay-out of the advantages of the drive. It varies with the class of material dealt with, and while it is obtainable with group, as well as with individual electric drive, it is in connection with the latter that it most definitely manifests itself. So far has this been recognised, that, to quote a recent writer, Mr. W. Sutcliffe, "one of the largest textile combinations in this country decided, some years ago, after considerable experience, to adopt individual driving for all machines other than those connected with the preparatory processes, the chief factor influencing the decision being the superiority of the drive for spinning and finishing, as shown by the improved evenness and quality of the finished goods. This firm has now upwards of 11,000 induction motors operating in their various mills, the great majority of these being under 10 h.p., of the squirrel cage type, and driving individual machines." When it is added that the author has, during the past ten years, and notwithstanding the war, installed over 15,000 individual drive motors, it will be clear that the merits of this drive have come to be recognised by the most conservative manufacturers.

The great advantage of any increase in productivity secured through improved methods of driving lies in the fact that it is obtained without any increase in machinery, in building space, rent, rates, or taxes, and its effect on profits is consequently more striking. The author was able to show, a few years ago,* that an increase of 10 per cent. in the production of a Lancashire weaving shed which was obtained through individual electric driving, was equivalent to an increase in profits of over 30 per cent., and while it has not been possible to obtain the detailed information necessary for a similar general investigation in the case of the jute industry, sufficient data has been obtained to show that for Indian jute mills in particular, the effect on profits of such an increase is more nearly 50 per cent. than 30 per cent.

* "The Individual Electrical Drive in Weaving Sheds." *Journal of the Association of Managers of Textile Works,* March, 1912.

Individual Drives in Weaving Shed



Belt Drive to Line Shaft

This is a striking result, and, in the author's view, furnishes a solution, if not indeed the only solution of the problem, that is facing the manufacturer who has put down a new mill, during or since the war, and finds himself forced to carry a very greatly increased capital expenditure, and, at the same time, to compete with mills erected in happier circumstances, and the greater part of whose capital has, in many cases, been written off.

If electricity furnishes the solution of this serious war problem, and the author believes that it does, it will, as the chairman pointed out in his opening remarks, have done for this generation what the steam engine of James Watt did for the generation that lived in the depression following the Napoleanic Wars—an achievement that it must be conceded would be no mean contribution to the solution of the peace problems of the world. The author desired to acknowledge his indebtedness to the Chairman (Mr. McKenzie) and the Committee of the Indian Jute Mills Association, for very valuable assistance; to the Chairman and Secretary of the Association of Jute Manufacturers and Spinners, Dundee; the Secretary, the Chamber of Commerce, Dundee; to Mr. T. L. Miller, of Dundee; and to Mr. C. R. Orr, Edinburgh, who kindly read through the proofs, and whose kindly criticism was very helpful; and, finally, to the English Electric Company, for permission to use the various photographs of plant.

CORRECTION

In our December issue the caption under the illustrations of the Garrett patent locomotive had been transposed; that under photo on page 275 applying to the engine on page 276, and that under the illustration on the latter page applying to the engine on page 275.

ROLLER BEARINGS FOR RAILWAY ROLLING STOCK

The English daily papers have recently been printing somewhat exaggerated accounts of the tests being carried on by the Great Eastern Railway Company in connection with the use of roller bearings for railway rolling stock. While, however, their optimistic forecasts as to the economies likely to result from the successful outcome of the experiments now being conducted must be discounted, there is undoubtedly great interest being taken in the matter in view of the advantages to be gained from the effective use of roller bearings. Of course, the idea is not at all new, and the bearing, which was first introduced in Sweden, has been applied to passenger train vehicles in that country with marked success. It is also now being applied to a complete passenger train in England. The chief difficulty hitherto experienced, has been to discover a metal which would stand up to the load imposed upon bearings by heavy rolling stock, but recent research work has rendered it possible to specify a steel which, it is claimed, will meet all requirements. The subject is of the greatest importance in view of the effect on haulage costs which would be associated with the successful adaption of roller bearings to railway vehicles.

In the design under trial the bearing includes a series or rollers of particularly hard but not brittle steel, mounted in a chain-type carrier, and arranged to run between two annular members, one surrounding the axle, and the other fitted into the axle-box. In yard tests a stationary 27-ton vehicle can be moved by one man on level track, and the further tests now proceeding are intended to show whether the rollers will withstand heavy service conditions. We shall watch developments with interest, and return to the subject in due course.

The "Brotherhood-Still" Heavy Oil Engine

The data and illustrations for this article have been supplied by courtesy of Messrs. Peter Brotherhood Ltd., Peterborough

WE illustrate in this article a new design of prime mover, embodying the well-known "Still" principles. This new engine has been put on the market by Messrs. Peter Brotherhood Ltd., of Peterborough, and the diagrammatic view gives a very clear idea of its general construction and arrangement.

It will be noted that the oil engine side of the piston operates on the 4-stroke principle, and the steam side is operated with quick action piston valves.

The general principles involved, from a practical point of view, follow, of course, the "Still" idea, wherein the heat of the exhaust gases and from the water jacket are utilised to supply steam to the lower side of the main piston, resulting in a prime mover of very much greater efficiency than the pure "Diesel" engine.

The heat balance chart illustrated, kindly supplied by Messrs. Peter Brotherhood Ltd., shows very clearly where the different heat losses take place, and also how a portion of these losses are utilised for developing useful work in the new design.

Researches and experiments by this firm, extending over many years, have now resulted in a heavy oil engine showing an economy hitherto unattained in any form of prime mover which relies on combustion of fuel for the production of power. The fundamental principle of the Still patents is the recovery of heat which in other types of internal combustion engines is lost. The two main sources of loss are the heat absorbed by the water jackets and that passed out in the exhaust gases. In the Still engine a large proportion of both is converted into steam, and used to develop additional power in the engine.

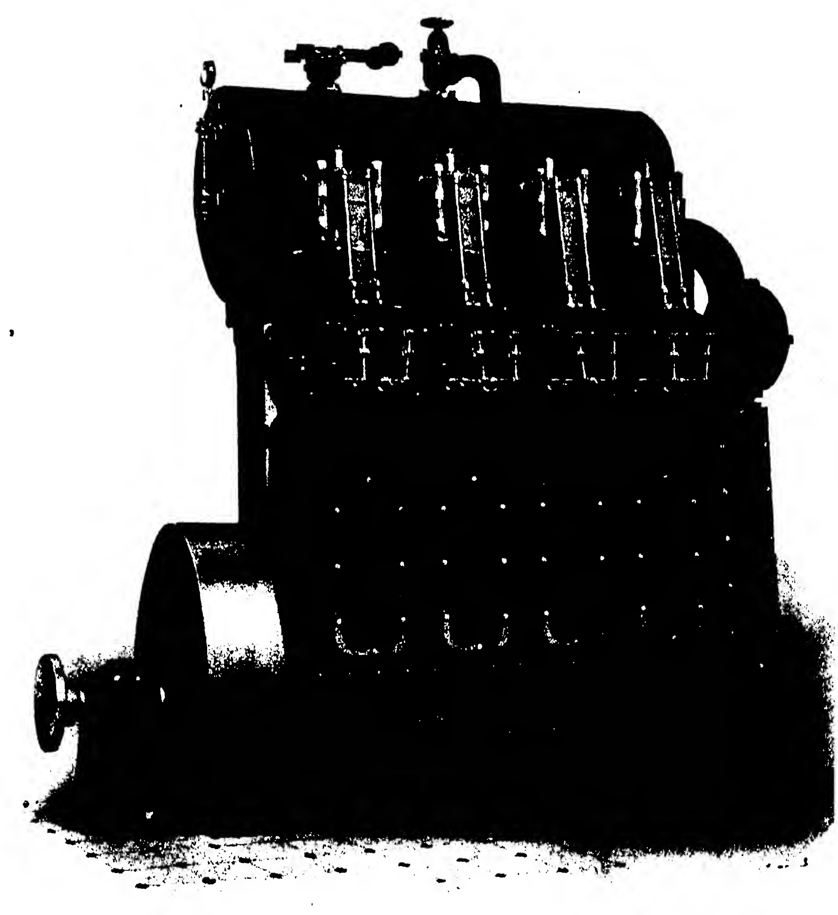
An engine working on this principle may rightly be described as a combined internal combustion and steam engine, possessing the merits of both, and suitable for use in almost any case where power is required, and liquid or gaseous fuel is available.

The "Brotherhood-Still" engines are supplied for any power up to 1,100 b.h.p., under guarantees as to reliability and economy.

The principle on which the Still engine works is shown diagrammatically on page 464. The engine is started by burning oil fuel under the regenerator, steam being admitted direct to the steam chest by opening the stop valve. It is then admitted to the under side of the piston by quick action piston valves driven off the camshaft, in precisely the same manner as in a steam engine. After the engine is turning round, the oil fuel is turned on to the fuel injection valve, to which the fuel is supplied by a solid injection pump.

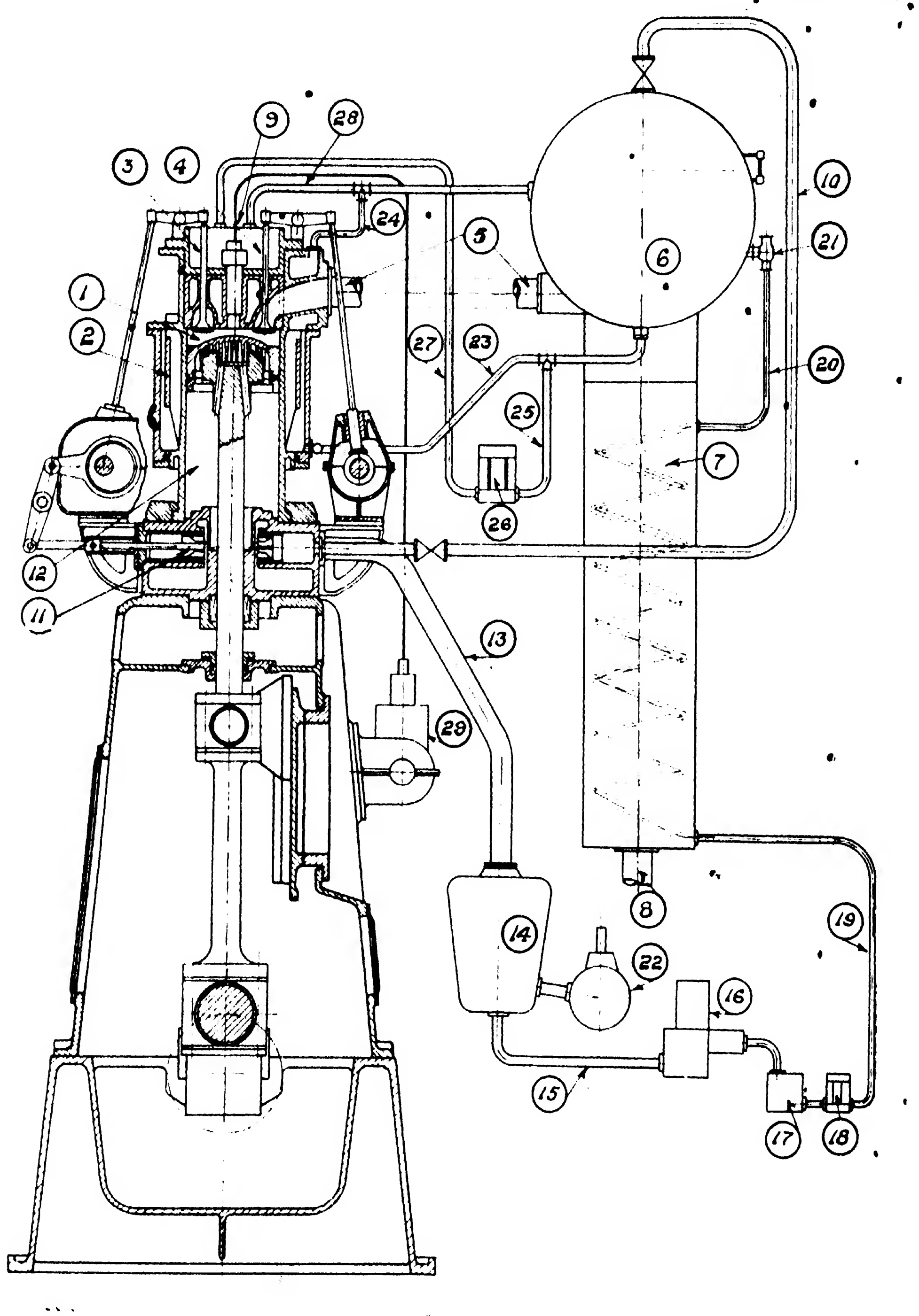
The exhaust gases are led to the regenerator, where their heat is absorbed in the generation of steam, and thence through a feed water heater to the exhaust outlet and atmosphere.

The water jackets form a thermo-



Brotherhood-Still Heavy Oil Engine

CHART No. 655



DIAGRAMMATICAL ARRANGEMENT OF 4 STROKE "STILL" ENGINE

For reference figures see page **465**.

circulating system in parallel with the regenerator, so that the temperature in the jackets is constant, and corresponds to the pressure of steam in the regenerator. By thus maintaining a relatively high temperature in the jackets, a much lower compression pressure is required to ignite the fuel, as the air takes up heat from the hot walls and piston during the compression stroke.

From the same cause, on the firing stroke the heat loss to the jackets is reduced, and the combustion efficiency correspondingly increased.

The steam, during admission and expansion, is at a lower temperature than the enclosing walls, and condensation in the cylinder, the cause of the largest loss in a steam cylinder, is avoided.

It will thus be seen that on the oil and steam sides of the piston, the internal losses are very greatly reduced, owing to the high temperature of the cylinder walls.

Reference Schedule

1. Combustion chamber.
2. Reinforcing steel hoop.
3. Inlet valve (combustion).
4. Exhaust valve (combustion).
5. Combustion exhaust pipe to generator.
6. Exhaust generator.
7. Feed water heater.
8. Final combustion exhaust to atmosphere.
9. Injection valve.
10. Main steam pipe.
11. Steam inlet and exhaust valve.
12. Steam cylinder.
13. Steam exhaust pipe.
14. Condenser.
15. Suction pipe to air pump.
16. Air pump.
17. Hotwell.
18. Feed pump.
19. Feed discharge pipe to feed water heater.
20. Feed discharge pipe, feed heater to exhaust generator.
21. Feed check valve.
22. Condenser circulating pump.
23. Circulating water: exhaust generator to jacket.
24. Circulating water: jacket to exhaust generator.
25. Circulating water: exhaust generator to circulating pump.
26. Cylinder head circulating water pump.
27. Circulating water: circulating pump to cylinder head.
28. Circulating water: cylinder head to exhaust generator.
29. Fuel injection pump.

Note: See page 466 showing diagram of heat balance.

Reviews

FILTRATION.—By T. Roland Wollaston, M.I.Mech.E. *Published by Sir Isaac Pitman & Sons Ltd., Parker Street, Kingsway, London, W.C.2. Price 2/6 nett.*

IN this little publication, which is marked No. 47 of the very excellent series of Pitman's Primers, Mr. Wollaston deals with the subject of "Filtration" in the space of about one hundred pages, and covers the subject in a very comprehensive manner.

It is, of course, quite impossible to deal with a subject of this nature in anything like an exhaustive manner in so small a space, but Mr. Wollaston has brought a practical mind to bear on the subject, and has recorded the salient features of each of the principal methods in use for the various departments of industrial filtration.

Chemical precipitation, coagulation and sedimentation are dealt with in relation to the filtration of water; the subject is then carried on to the physical action of filters, and in the third chapter the chemical and bacterial action in filtration is dealt with.

In Chapter IV the subject of cloth filters, filter presess, etc., is dealt with, when a number of leading designs of filters are described in some detail. This section is continued in Chapter V under the heading of "Filtration of Bublic Supply Water."

Chapter VI is devoted to the centrifugal and vacuum filtration method, and in Chapter VII the filtration and clarification of oil is dealt with.

Finally, in Chapter VIII the filtration of air is gone into, and it records some of the salient facts regarding the important subject of the air we breathe; where Mr. Wollaston deals with the evils of atmospheric pollution and the filtration necessary for ventilating buildings, and finally deals with one of the most recent developments in this subject, namely, "Electrostatic Precipitation."

We would like to say, in reviewing these little primers, that we cannot too strongly recommend them to our readers in a country like India, which has hardly yet touched the fringe of its industrial development. It is most essential that all those who have India's industrial development at heart should obtain at least an elementary knowledge of all fundamental industrial processes. Modern industry has become so complex, that even one small branch of industry is interconnected with a number of other branches, and no one can claim to be a specialist in any one branch without also having some fundamental knowledge of a number of other interconnected branches.

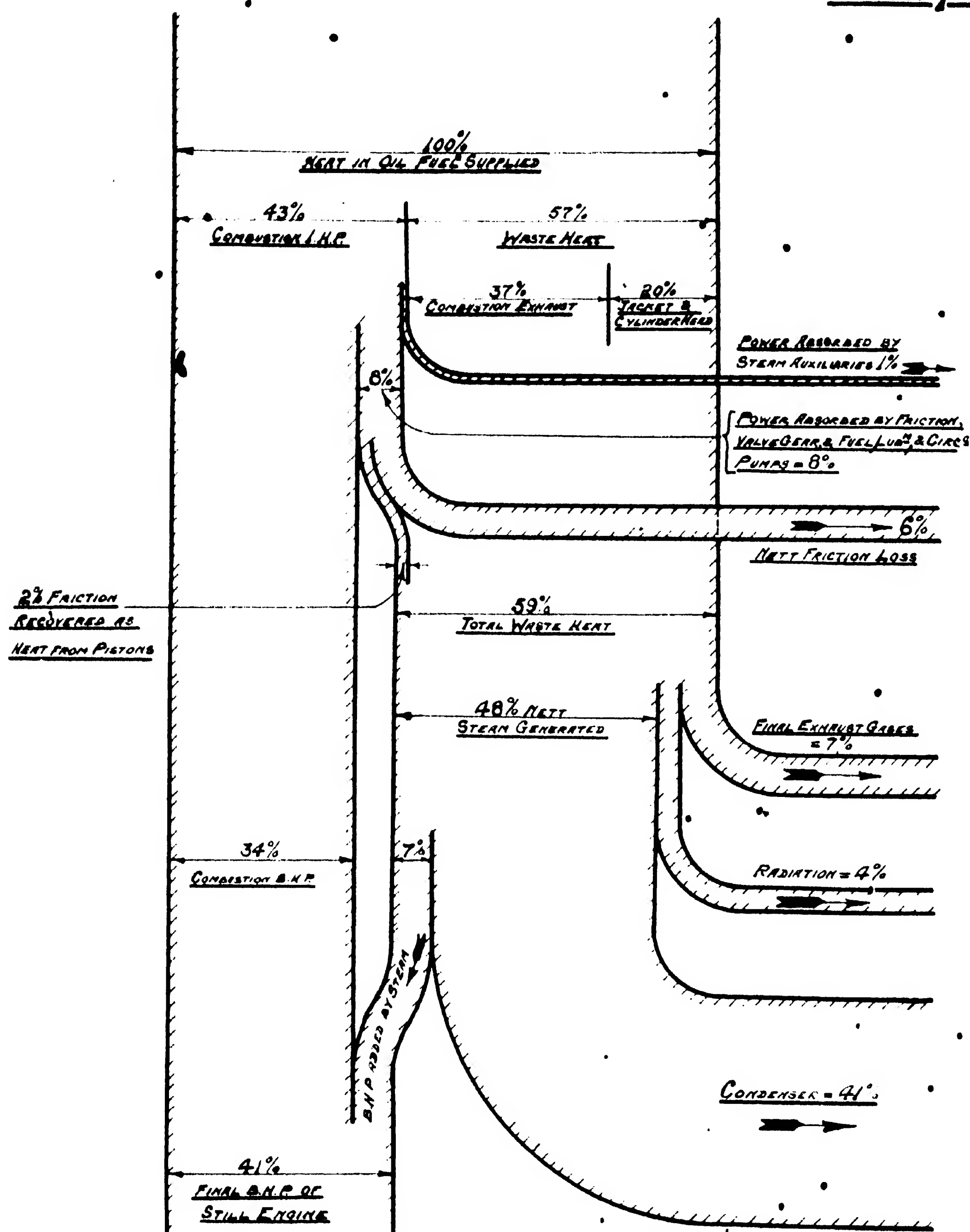
Another important value of these primers is that they give in simple language the elementary introduction to the particular branch of industry dealt with, and we would recommend to all our readers who write to us for advice in the starting up of various industries, to obtain a complete list of all primers published, when they would be able to secure at very little cost, up-to-date literature which would be a starting-point for their investigations.

THE SOUTH INDIA RAILWAY

THE Report of the South Indian Railway Company for the year ending March 31st, 1922, is an interesting one, and while it reflects the great increase in working costs, it also shows a satisfactory increment in gross earnings. For the year the gross earnings were Rs. 4,40,03,089, and the working expenses Rs. 3,15,57,197, the net earnings being, therefore, Rs. 1,24,45,892. As compared with the previous year, the earnings from coaching traffic rose by Rs. 9,80,323, goods traffic by Rs. 15,69,708, steamboat earnings by Rs. 2,30,559, and telegraph and sundries by Rs. 4,94,463. During the year Rs. 142,22,084 were expended on capital account, the major portion of this item being on the provision of locomotive and carriage and wagon stock, while important engineering works, involved in the provision of additional facilities at stations for dealing with traffic, strengthening and improving the permanent way, and the strengthening of bridges, cost a considerable sum. The "operating ratio" or percentage of working expenses to gross earnings was 71.71, this comparing with 60.98 for the previous year, and 54.55 for the year 1919-20. The growth of this item is serious, but it is hoped in the current year to be able to effect considerable reductions.

TYPICAL HEAT BALANCE OF 4 STROKE HEAVY OIL ENGINE (STILL SYSTEM)

CHART No/853



41% THERMAL EFFICIENCY REPRESENTS A FUEL CONSUMPTION OF ·345 LBS. OF OIL PER B.H.P. HOUR @ 18,000 B.T.U's/LB

See article page 463.

INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

Volume II APRIL, 1923 Number 9

BETWEEN OURSELVES

Electrical Equipment in Railway Service

SOME interesting figures relative to the utilisation of electrical equipment in railroad service are given in a recent issue of the American *Railway Electrical Engineer*. On the New York, New Haven and Hartford, which has 550 miles of electrified track, each locomotive averaged 60,000 miles annually, and there was only one failure per 33,000 miles. The freight locomotive mileage per locomotive failure was approximately 22,500, and it is worth noting that, while these locomotives make two round trips aggregating 272 miles per day, the daily locomotive mileage under steam operation was between 100 and 120. Electric shunting locomotives have replaced steam locomotives in the ratio of 2 to 1, and have realsied a coal saving of 65 per cent. As showing the hauling possibilities of the electric locomotive, it is pointed out that on the Norfolk and Western Railway, two 300-ton electric locomotives now haul trains of over 3,000 tons at 14 m.p.h., whereas previously three Mallet steam engines were required, the speed then being 7 m.p.h. Reliability in operation is another advantage claimed for the electric locomotive, and the experience of the Pennsylvania Railroad is of value in this regard. On the Philadelphia suburban service of that railroad, about 600 trains per day are now operated, as compared with 160 under steam conditions, while during a recent year, when nearly 3,000,000 car-miles were run, there was an average of over 48,000 car-miles per detention. Similar useful figures are given relative to service on the New York, Westchester and Boston, and the Chicago, Milwaukee and St. Paul Railways, all indicating that where electrified working has been introduced it has proved to have advantages over steam practice, both in connection with availability, reliability, service and cost.

* * *

A New Harbour for Kiel

IT is claimed that Kiel is one of the best natural harbours in Europe, and that, being situated on a main line of traffic, it possesses many advantages as a commercial port. Considerable developments are pending in connection with the reconstruction, and, according to the *Shipbuilding and Shipping Record*, a large closed industrial harbour is to be established at Vossbrook, north of the mouth of the Nord-Ostee Canal. There are to be 8,200 feet of quays and extensive warehouses, and it is understood that while the development of the harbour will be entrusted to a large company, both the State and the town will retain an interest. Kiel has excellent facilities at other harbours. In the Wik there is about 3,280 ft. of deep-water quay space, with 2½-ton and 1½-ton electric portal cranes, together with 54,000 square feet of sorting and storage space. At the north harbour there will be 1,640 ft. of quays, with 28 ft. of water and at least 65,000 square feet of warehouse space. Additionally, there is a 12,000-ton silo-storage, with 500 ft. of quays and a complete pneumatic conveying installation, which will provide for the direct transfer of grain either to storage or into railway wagons or Baltic vessels.

The East Indian Railway Company

AT the 75th half-yearly general meeting of the East Indian Railway Company, held in London, on January 24th, the Chairman (Sir David M. Barbour, K.C.S.I., K.C.M.G.) stated that the gross earnings of the undertaking for the half-year were Rs. 797 lakhs, as compared with Rs. 755 lakhs in the corresponding period of the previous year, and with Rs. 729 in 1920. Of course, in connection with these improved figures, it has to be remembered that fares and freights were higher, and they had actually carried less goods traffic and fewer passengers. The expenditure for the half-year came to Rs. 488 lakhs, as compared with Rs. 430 lakhs in the half-year ending September 30th, 1921, this being an increase of 13.49 per cent. The operating ratio rose from 56.98 to 61.25 per cent., and this required careful examination. To realise improvement, especially in connection with claims, the railway watch and ward department was being reorganised, the commercial department strengthened, and other arrangements made. The Chairman said he was glad to notice that, while there has been a considerable trade depression in India, trade now seemed to be reviving, and there could be no doubt that, on a line such as the East Indian Railway, there would be a continuous growth of traffic carried and of gross receipts, although there might be occasional set-backs. It was also reported that Sir Robert Highet, Deputy-Chairman, had gone to India on business connected with the Company's property.

The Omnibus versus the Tram

As an extremely useful and essentially mobile transport medium, the motor vehicle has definitely established itself in all parts of the world. Even in big cities, where electrified tramway services are operated, opinion is now tending towards a preference for the petrol-driven omnibus as a more effective agent for the transportation of dense crowds of passengers. One thing is certain, the omnibus has a flexibility all its own. Whereas the trams are tied to their lines of rails, the omnibuses can deviate from their normal course as occasion requires. In the case of a densely-operated tram service, moreover, it frequently happens that there is congestion caused by the relatively long stoppage, possibly owing to a slight defect, of the leading tram, with the result that the whole line becomes immobile unless there is some convenient junction where they may diverge on to other tracks. Not so with the omnibus. Its flexibility, possibly manifested at its highest point in London traffic, enables each unit to run entirely independent of others. Apart from its determined stops, and detentions by order of the traffic-regulating police, each 'bus is able to get about its business at a fast over-all speed, and there can be little doubt that comparison on a fair basis between the tram and the omnibus would show an overwhelming advantage for the latter, both in cost of operating and convenience. Recognition of this fact is undoubtedly prompting the development of omnibus services in many quarters as distinct from tramway extensions.

* * *

Great Indian Peninsula Railway Company

It is an interesting commentary upon the progress of the Great Indian Peninsula Railway to notice that the "operating ratio," which was 95.49 per cent. in the corresponding period of the previous year, had been reduced to 84.63 per cent. for the half-year ended September 30th, 1922. Commenting upon the serious character of this burden at the time, we ventured the opinion that great improvements would soon be made, and are confirmed in our views by the figures now before us. On September 30th, 1921, the Company was faced with the heavy deficit of Rs. 144 lakhs, whereas on September 30th, 1922, the deficit has been reduced to Rs. 84 lakhs. Gross earnings increased 6.40 per cent., and expenditure decreased 5.70 per cent. in the half-year. Mr. J. E. Dallas, Managing Director, who presided at the meeting, in the place of the Chairman, Sir Charles Armstrong, who was absent in India on the business of the Company, stated that while the long-wished-for revival in trade did not materialise in 1922, they had at least made progress in the right direction. He further intimated that the expenditure side of the account was being subjected to rigorous examination, and no pains were being spared to enforce every economy that could be effected without impairing efficiency. Sanction had been received, said Mr. Dallas, for the electrification of the first 30 miles of the Bombay suburban electrification, and contracts would shortly be let out for the track-work and special rolling stock.

* * *

Rohilkund and Kumaon Railway Company

The ordinary general meeting of the Rohilkund and Kumaon Railway Company was held in London on January 23rd, when Sir Henry P. Burt, K.C.I.E., C.B.E., Chairman and Managing Director, who presided, announced that the financial results for the year ended September 30th, 1922, were not quite so satisfactory as in the previous year. The gross receipts of the undertaking showed an increase of Rs. 5.2 lakhs, or 8.8 per cent., this being due mainly to the higher rates and fares levied, as there had been no appreciable improvement in the volume of passenger and freight traffic carried. On the other side of the account, working expenses had advanced by Rs. 5.6, which absorbed the gain in the gross receipts, the result being that the net earnings actually showed a decrease of Rs. 39,301, while the "operating ratio"—the percentage of working expenses to gross receipts—had advanced from 52.05 per cent. to 56.61 per cent. With regard to extensions, the Chairman said that the Company had never hesitated in the past to develop the area served by the railway whenever the traffic prospects justified the expenditure, but there were now difficulties in the way. One project, a line from Kashipur to Kalagarh, was being urgently pressed for by the Local Government, to develop the large timber resources of the Patli Dun, and while there was little doubt that in due course the branch would give a satisfactory return, for some time they were not expected to afford a return of 3½ per cent. On this basis they could not at present entertain the proposal, while they had also to remember that their contract might be terminated in 1932.

* * *

The World's Shipping

The world's record year for shipbuilding was 1919, when vessels aggregating 7 million tons were launched. Since then there has been a progressive decline, and for a considerable period the shipbuilding industry has had a very lean time. From "Lloyd's Register Annual Summary of Shipbuilding during 1922," which has recently been published, it is noted that throughout the world only 852 vessels were launched during the year, the aggregate tonnage being, roughly, 2½ million tons gross. This is an appreciable decrease as compared with 1921, when nearly 4½ million tons gross was the output. Fortunately, however, there has recently been a great increase in the activities of those interested in shipbuilding, and it is confidently expected by those in a position to know that the present year will have a far bigger output than 1922. The returns show that in Great Britain and Ireland 91 vessels of between 5,000 and 10,000 tons each, and 17,000 vessels of 10,000 tons and upwards were launched, the *Franconia*, of 20,000 tons, being the largest. Considerable progress was made during the year in the use of steam turbines, while of the many motor vessels launched, nine were of 5,000 tons and upwards, with one of about 9,500 tons. The main countries contributing to the foreign-built tonnage are Germany, France, Holland, United States, Italy and Japan.

* * *

A North Sea Train Ferry

"Breaking bulk" in freight transport work is one of those functions that is both expensive and, oftentimes, unnecessary. It is axiomatic that transport costs are largely dependent upon the "terminal" functions, and where it is possible to eradicate the time and cost involved in transference from railway to railway, or from railway to sea transport,

or *vice versa*, it is extremely important to do so. It is for this reason that train ferries are proving so popular in many quarters, and the most recent to be established is that between Harwich, on the East Coast of England, and the Continent. Instead of all traffic having to be handled four times, as at present, the use of the train ferry will cut out two handlings, and will expedite the transits. There are many such train ferries now operating with advantage. Both in the United States and Canada they are a regular feature of railway operation, while the best known in Europe are the Treleborg-Sassnitz, the Waremunde-Gjedser, the Korsoer-Nyborg, and the Copenhagen-Malmo, all of which give communication with Denmark. The sea distances traversed range up to between 50 and 60 miles, but in the United States the well-known Lake Michigan route is 240 miles long. There can be little doubt that train ferries will be one of the most important future developments in connection with railway operation, as wherever they have been used, they have proved to be profitable and advantageous.

* * *

Feeders to the Main Line Railways

IF a country's resources are to be developed to the greatest possible extent, it is essential that there should be adequate auxiliaries to the trunk railway lines. These may take the form of light railway facilities, or road motor vehicles, though in the latter case it is usually necessary to have reasonably good roads. Canals and waterways, where such are available, may also be used to a limited extent, but except for specific classes of traffic, they are unable to compete effectively with a light railway or a well-arranged road motor service. There is considerable disagreement as to the best means of solving what might be called the pioneer transport problem, and advocates of light railways, road motor services, etc., naturally adhere to their special field, but the truth is that each case should be decided on its merits. Nowadays, there are composite means available for developing transport in difficult districts, and these have a special claim for consideration. There is the loco-tractor, or the road-rail system of traction, to which extended reference has been made in these pages, and there is also the newer idea termed the "Motorailer." Neither of these can be dismissed lightly in contemplating the improvement of transport facilities in difficult districts, as both of them possess advantages, both in regard to first cost and maintenance, that entitle them to careful consideration.

* * *

New Liner for the Orient Line—Vickers' Latest Order

AFTER a period of stagnation in the shipbuilding and marine engineering industry at Barrow, unprecedented as regards the dearth of orders in the history of the town, Messrs. Vickers Limited have succeeded in the face of very keen competition, in securing new work for their Barrow establishment, in the form of a first-class passenger liner of approximately 20,000 tons measurement for the Orient line.

The Barrow Works of Vickers Limited have in the past been the cradle of many of the finest and most famous naval and mercantile ships which the world has seen. The name of Vickers is almost household where naval shipbuilding of the very highest class is concerned. The splendid workmanship for which Vickers Ltd. have become justly famous is equally demonstrated in their production of ships for the mercantile marine, and there is no doubt whatever that the Orient liner which they have now contracted to build will, when completed, worthily uphold the great traditions of the Vickers firm.

The propelling machinery will be turbines, driving through single reduction gearing, and the boilers will be arranged for oil fuel.

When completed, the vessel will be a handsome addition to the already fine fleet of ships operated by the Orient Line, and will take up service between Great Britain and Australia—a further link connecting the Homeland with its most distant outpost of Empire.

* * *

Mechanical Stoking for Marine Work

A VERY interesting and most successful series of trials have been completed with the Underfeed type "E" mechanical stoker, as supplied by Messrs. The Underfeed Stoker Co. Ltd., of London, on two Dutch vessels belonging to the Koninklyke Paketvaart Maatschappy, of Amsterdam.

As is well known, mechanical stoking has never made any real headway at sea, although some of the earliest stokers of nearly a century ago were designed specifically for marine work. The Dutch steamship company in question first equipped their ss. *Bintoehan*, which is fitted with "Babcock and Wilcox" marine boilers, with the Underfeed type "E" stoker because they were not able to get full output on the boilers with hand firing, and a detailed series of trials was then carried out on short voyages in the North Sea between Holland and England, chiefly between Amsterdam, Hull, and Newcastle. The results were very satisfactory, the stoker giving a substantial economy in fuel, being absolutely smokeless, and not being affected by the very roughest sea. The ss. *Bintoehan* was then sent on her first voyage with mechanical stokers in May last to the Far East (from Amsterdam to the Dutch East Indies), and the result of this first long voyage has been a great success. There was no hitch at all, the steam pressure being maintained absolutely steady, equal to oil firing, whilst the combustion was smokeless, with about 12 per cent. CO_2. The most careful observations were made throughout the voyage, and the net results, as compared with an exactly similar vessel on the usual hand firing, were 10-15 per cent. saving in the coal bill. The working conditions in the fire-hole were also revolutionised, being practically equal to oil firing, whilst the steam pressure was maintained absolutely constant, which is not possible with hand firing, because of the cleaning out at the end of each watch.

A second vessel, the ss. *Parigi*, was then fitted with the same "E" type of Underfeed stoker, but in this case the combustion chamber of the "Babcock and Wilcox" marine boiler was enlarged, being made 2 feet higher. This question of cramped combustion chambers is a sufficiently serious matter on land, but it is even worse in marine work. The result of raising the boiler in the ss. *Parigi* only 2 feet has made a still further substantial economy, equal to about 6 per cent. additional saving, and this vessel also has made a voyage from Holland to India and back, with the most highly satisfactory results.

Mr. Muller, the Chief Engineer of the Koninklyke Paketvaart Maatschappy, is convinced that a great improvement has been made in marine steam generation, enabling both mechanical stoking and the water-tube boiler to be applied to the mercantile

marine. It is stated also that all new vessels for this steamship company will be equipped in future with these mechanical stokers and water-tube boilers, and it looks as if a definite and important step was about to be made at last in the direction of increased efficiency in steam generation at sea.

* * *

The "Sulzer" Diesel-Electric Locomotive

The "Diesel" engine locomotive promises to be a more formidable competitor to the steam locomotive than the application of electric drive from overhead wires, as we have observed on previous occasions, particularly for heavy long distance traffic, such as in India. The chief pioneer in the "Diesel" locomotive is undoubtedly the Swiss firm of Sulzer Bros., and they supplied one of the first successful locomotives of this type to the Prussian State Railways in 1913. This was an express locomotive with a two-stroke cycle four-cylinder "Diesel" engine driving direct by coupling rods on to the main centre driving wheels, the engine cylinders being placed in pairs, developing a total of 1,000 h.p., with train speeds up to 50 miles per hour, the auxiliary engine for starting and supplying compressed air for oil injection and scavenging being 250 h.p.

Messrs. Sulzer Bros. then began to develop also the idea of a "Diesel-electric" locomotive, in which a "Diesel" engine was direct coupled to an electric generator and the locomotive driven by electric motors geared direct to the driving axles. Several locomotives of this type were delivered to the Saxon and the Prussian State Railways and had a satisfactory practical test in 1914.

The war, however, interfered with progress in this direction in Germany, but Messrs. Sulzer Bros. continued to experiment, and have now effected a number of improvements. One of the most important alterations is the use of a solid injection type of "Diesel" engine, thus doing away with the troublesome air compressor and the intricate valve and control mechanism. The new "Diesel" electric locomotive, in the design of which it may be stated the firm of Messrs. Brown Boveri have collaborated with Messrs. Sulzer Bros. as regards the electric equipment, is built in the form of combined rail car, that is, locomotive and coach in one, but it can also, in addition, haul several passenger coaches as trailers. The overall length of the locomotive coach is 70 feet, the body of the coach resting on two bogies, one of which has three and the other two axles. When empty, the total weight of the coach is 66.52 tons, 38.65 tons being carried on the 3-axle bogie, the weight being 12.88 tons per axle. The motor bogie carries 27.87 tons, or 13.93 tons per axle. The "Diesel" engine unit consists of three pairs of cylinders, in "V" form, with their axles along the length of the carriage, and running at 440 revolutions per minute, developing 200 h.p. with an overload of 250 h.p. The speed is up to 44 miles per hour, and sufficient oil is carried in the tanks for 300 miles. An ingenious water cooling device is part of the installation, the warmed water heating the carriages on the way to the cooler, whilst the electric generator works at 300 volts, and is of 140 K.W. normal capacity. The installation has had a thoroughly practical test of a number of weeks on the Swiss Federal Railways, over the Baden-Niederglatt section, and has given the greatest satisfaction, so that a second locomotive is to be put in service on the Berne-Neuchatel section of the Lotschberg railway. The costs are said to be very much cheaper than an electric locomotive, even in Switzerland, with its extensive water-power development, and a great advantage over the steam locomotive is the absence of stand-by losses, and the saving of time in the engine sheds and depots.

* * *

Mechanical Stoking

The chief event of interest at the annual meeting of the American Society of Mechanical Engineers, held in New York in December last, was a group of papers on "Mechanical Stoking," with a lengthy discussion.

One of the striking features is the number of modifications that have been evolved in America of the chain grate stoker, the original invention of an Englishman, John Juckes, in 1841, and in the "compartmented" air supply modifications with mechanical forced draught, it is claimed that 55-60 lb. of average quality coal can be burnt per square foot of grate area without the passage of excess air through the back of the grate.

The proceedings served to show again that two of the original troubles of mechanical stoking, encountered a century ago when the principle was first introduced, remain with us to-day, that is, wear and tear, and the difficulties in connection with fluctuations in the demand for steam. Also it is being more or less realised, unfortunately to a greater extent in America than in Great Britain, that a mechanical stoker is a delicate machine, which, like any other mechanism, must be operated with intelligence, an important point under Indian labour conditions. The idea fostered by some stoker makers themselves, that a mechanical stoker is "fool-proof," is ridiculous, and entirely without foundation; as is well-known to many steam users.

The meeting in America was concerned, however, almost entirely with mechanical stoking as applied to the externally fired water-tube boiler, but in Great Britain, as in India, the chief interest centres on the internally fired cylindrical boiler, especially of the "Lancashire" type. Mechanical stoking, as applied to this kind of boiler, is much more difficult, because of the very narrow grates (usually not over 3 ft. 6 in.), and the necessity of bringing the ash and clinker back through the front of the boilers. It is therefore not an easy matter to give a general opinion as to whether mechanical stoking under these conditions is preferable to hand firing or not, but very briefly it can be said that there is little difference in efficiency between mechanical and hand firing, and the general advantages of mechanical stoking for cylindrical boilers are much better labour conditions in the firehole, the possibility of the proper application of mechanical coal and ash handling, and less smoke, whilst the disadvantages are wear and tear, excessive consumption of steam by the furnace nozzles, cost of upkeep, and lessened flexibility, both as regards steam output and ability to burn different grades of coal, the latter being a particularly important point for Indian conditions.

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Commencing with our May issue, Industrial India will be carried on under a new joint ownership. Mr. J. R. Sarjantson, who has acted as Editor from the first number, will from this issue assume full control and management, and Messrs. The Tata Publicity Corporation Ltd. will retain a part financial interest, and will continue to act as the Publishing Agents in India.

INDUSTRIES

Conducted by FRANK DAWSON

IN THIS SECTION WE CONTINUE OUR SURVEY OF INDIA'S INDUSTRIAL DEVELOPMENTS

Cardboard Boxmaking and Machinery

By V. H. SEYMER

Illustrations by courtesy of Messrs. Vickers Ltd., Erith

IT is only necessary to consider the variety of purposes for which cardboard boxes are used, when it will be realised that it is impossible to touch more than the fringe of their manufacture within the compass of an article. It is not generally recognised that this industry yields a large return. The capital outlay of installing plant is small compared to the high turnover obtained. The majority of boxmaking firms are in business for that purpose alone, but a box factory is often conducted by wholesalers as an ancillary department. In that case inside needs are first satisfied, and when packings have been provided for the products made, any surplus production of boxes is profitably disposed of outside.

It may be well here to review the history of the industry. This is a very old one, but its full development is of comparatively recent date. As early as the middle of the 18th Century, hand-made and elaborately decorated bandboxes were hawked in the streets of London, and quaint old prints still exist to record these long-forgotten pedlars with their gay burdens.

Life was leisurely and informal in those days, and the vendor of all classes of goods came in search of his buyer, instead of making a display behind plate-glass shopfronts to attract the citizen on the pavement. Trading was done at the dwelling-house doors, and the only advertisement was the festive wares themselves bobbing along the cobbled streets on the backs of hawkers who threaded their way through the rest of the traffic. Whatever may be said for or against this "personal" method of doing business, the hawkers must have been a very picturesque and characteristic feature of old London, and among them the boxmen were prominent figures, by reason of their number and their brightly-coloured, bulky stock-in-trade. These men were the salesmen of their day, and, as such, can be fairly remembered as pioneers of what is now a great industry. And now as to the buyers who first created a demand for cardboard boxes. They were mostly the ladies of the time. Restless as ever, the fair sex would travel. The trunk of to-day being unknown, something must be found in which to pack easily-crushed dresses and voluminous hats; and so we see the preparations for a journey by post chaise starting with an acknowledgment from a window of the hawkers' cries, followed by a little bargaining and the purchase of the necessary equipment of flower-bedecked boxes.

Gradually, a cheaper and less strong form of these boxes came to be used as a container in which to sell these same hats and dresses, and its use extended sufficiently to establish the boxmaker in regular business.

There followed a period in which little progress took place, until the wonderful prosperity of the country in the second quarter of the 19th Century began.

England was expanding to the position of the premier industrial country of the world. All kinds of manufacture were opened up coincident with the establishment of the railways, and with the general fillip given to home industries, the price of cardboard and paper declined; new methods were discovered, and its quality and strength were improved; the cheapness and convenience of cardboard boxes for the distribution and sale of all kinds of goods was discovered. Hawkers and street stalls gave way before retail shops, who expected to receive their supplies properly boxed from the wholesale warehouses. Export trade doubled, and cardboard boxes became imperative to reduce wastage in transport.

The boxmaking industry thereupon "came downstairs." The squalid little garrets in which it had been carried on gave place to properly planned factories.

This, then, is the state things had reached at Home when India first made its acquaintance with the cardboard box, in which textiles, foodstuffs, drugs, leather goods, and other imports were packed. The growth of India as a consumer of home products had its effect—and a very substantial one—on the development of boxmaking at Home. But, until recent years, most goods were imported in retail packings, and there was little movement towards production of boxes in India. With the great strides Indian industry is now making, the country will soon be standing on its own feet We are already witnessing the same process in India as we have seen at Home. The street hawkers and stalls of the 18th Century may be not inaptly compared with the bazaars. As the former were in this country, so are the latter in India being gradually engulfed by the modern shops. These last are no longer chiefly patronised by Europeans. Indians of all castes now buy in, and keep shops, and this implies boxed goods. Not only that, but it implies *Indian* goods boxed, and the result is that the first boxmaking factories are being opened in India to cope with the demand for these packings. There can be as yet no data on which to base a forecast of the ultimate development of box-

making in India, but it is safe to predict a great expansion, and some idea can be formed already.

Consider, for instance, what products are boxed in Europe, and what is the extent of the boxmaking industry which these products support. Then examine which of these are now, or soon will be, manufactured in India. There are textiles, soap, matches, drugs, tobacco, confectionery, boots, foodstuffs, toys, electric and engineers' fittings, clothes, hosiery, hardware, turnery, tools, hats, jewellery, stationery, polishes, oil and colourman's goods, and many others.

This work employs some 800 box factories in the United Kingdom alone. All the boxes made are destroyed after once being used, and quite a normal output for one factory would be half a million boxes per week. Thus large total profits are yielded by the smallest profit on each dozen boxes.

Passing, now, to the machinery for the equipment of these factories. The first of the special machinery for boxmaking was produced in Germany, whose example was soon followed by England and America. At the outbreak of war, this work entirely occupied about fifteen engineering concerns of major importance in those countries, besides a number of smaller works. Approximately, four million sterling was invested in these undertakings, and the export of boxmaking machinery from Germany alone, in 1913, apart from their home consumption, totalled close upon £600,000.

Messrs. Vickers Ltd., of Erith, whose machines form the illustrations of the present article, have now entered the field, and occupy a leading position among box machinery engineers at Home. This firm is among the first to make a bid for England in this branch of engineering.

Broadly divided, the various forms of cardboard container in use to-day fall into three categories.

First, there is the "Rigid" type, which may be either "paper-covered," "wire-stitched," or "metal-edged," according to the finish and strength required. In general, paper-covered boxes are less strongly made and more attractively finished than the other two varieties, and are seldom made in the larger sizes.

The machines used are shown below:

A is the rotary cutting and scoring machine, which, with normal sizes of work, will prepare about 2,000 boxes or lids per hour, working from the crude sheet of cardboard.

In its various forms, and with suitable equipment, it can be used for all classes of rigid box in every size.

Its function is to convert the crude sheet of cardboard into a number of separate rectangular pieces, known as "blanks." Each of these blanks leaves the machine cut to the exact size of the box or lid to be made (when these are opened out into the flat state). The blank is also prepared for folding, so that the ends and sides can be folded up into position in relation to the bottom.

When this is done the blank has the appearance shown in Diagram 1, and is passed to the double corner cutting and slotting machine (Fig. B).

This machine, as well as machine A, is used for either paper-covered or stitched work. Its function is to cut out the four corners of the blank, and so make it ready for fixing at the corners.

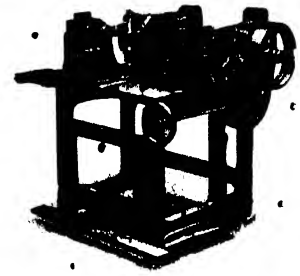


Fig. B.

For a covered box the heads will be set to cut out the corners clear (Diagram 2). The corners will also be cut in this manner, for corner-stitched or metal-edged boxes. These

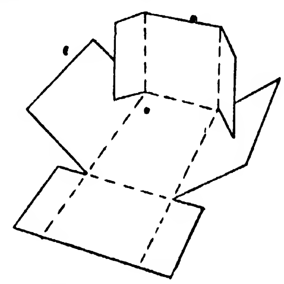


Diagram 1.

methods of fixing the corners will be alluded to later.

For an ordinary wire-stitched box, a flap must be left on the corner for

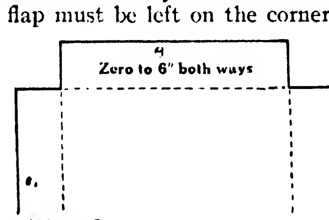


Diagram 2

stitching, and the heads of the machine can be set to provide this, as per Diagrams 3 and 4.

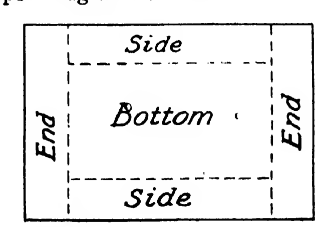


Diagram 3

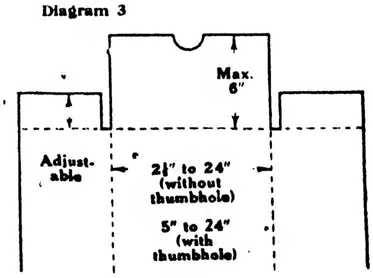
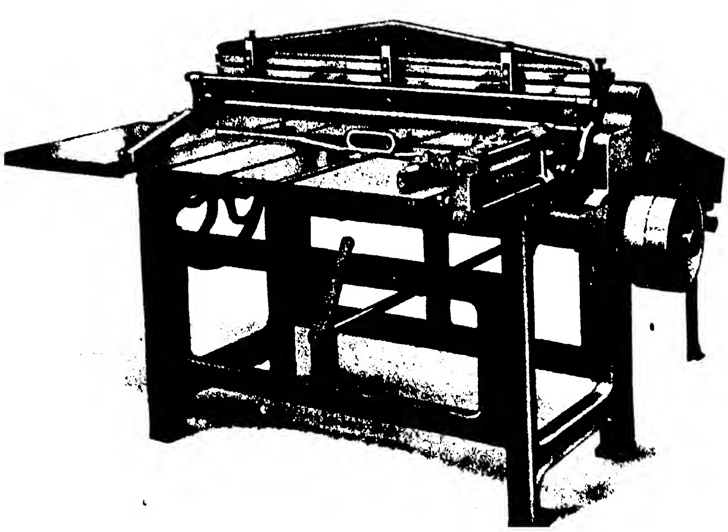


Diagram 4



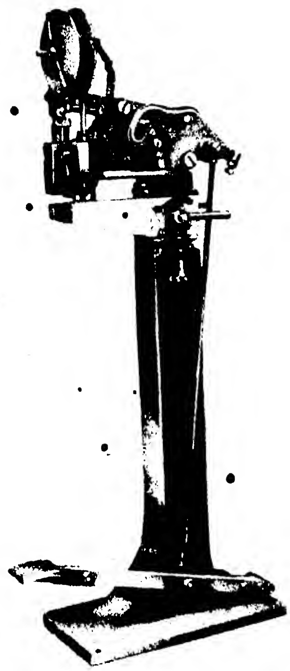


Fig. C.

The two machines A and B are the only types common to both covered and uncovered boxes. After leaving the corner cutter, the blank for an uncovered box is passed to some type of stitcher, or else to a metal edging machine, which fixes the corners by inserting wire staples or by a metal corner strip.

Fig. C shows a treadle-operated wire stitching machine, and Fig. D a heavier power-driven machine for the same purpose.

Both these machines work upon the flap left by slotting on machine B. as stated above if the corner has been cut out, as in Diagram 2, then either *corner stitching* or *metal edging* will be used for uncovered boxes. The former machine, shown in Fig. E, is made for either treadle or power operation, and wraps a wire staple round the corner of the box.

The metal edging machine (Fig. F) fastens the box corner by pressing on to it a prepared form of metal strip. This is provided with teeth which securely clamp the edges of the board together.

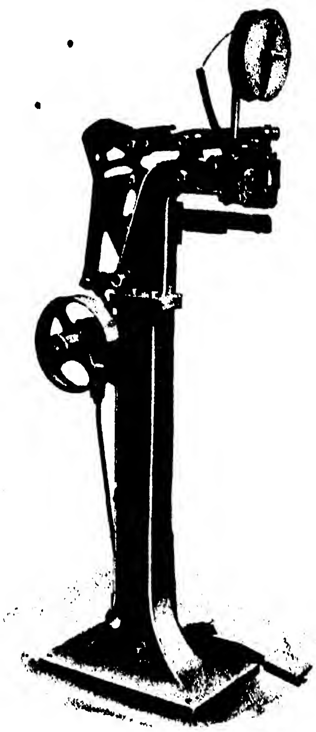


Fig. E.

Fig. G.

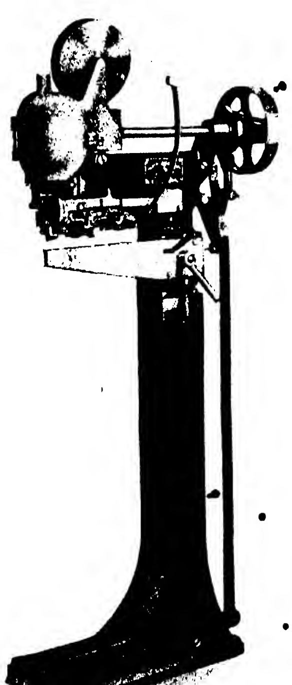


Fig. D.

All these fixing machines are automatic, drawing the wire or edging from a reel, and the setting for different depths of box is instantaneous.

The fixing machines above described are for uncovered boxes only. For covered work, the blank, when leaving the corner cutter B, will be passed to machine G, the corner staying machine, which fastens the edges of the board by means of a strip of gummed paper, which does not show through the paper cover to be later applied, and has no corrosive effect due to the adhesive with which the latter is fixed to the box. It is this corrosive action which precludes wire stitching or metal edging for covered work.

When the box is stayed, it is in its final form, and has only to be covered with paper by the banding machine (H). This machine covers the sides, ends, top and bottom of the box from

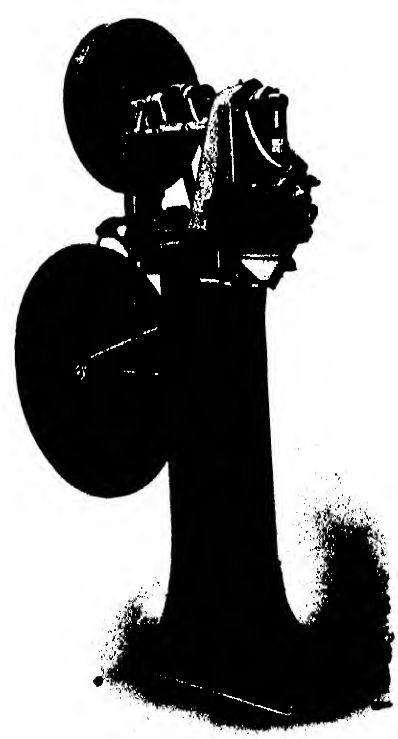


Fig F

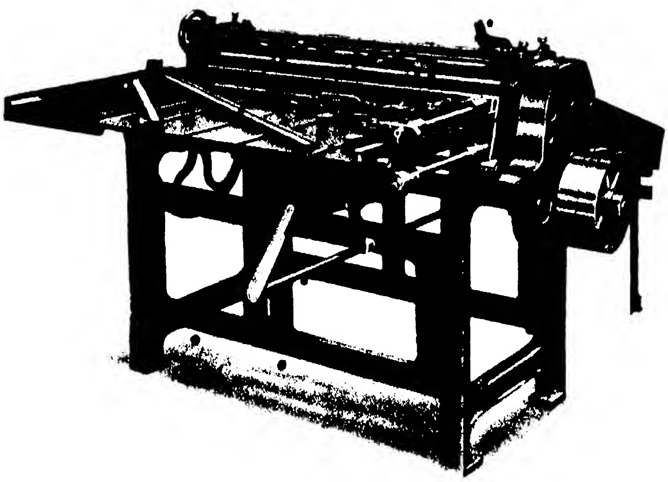


Fig. I.

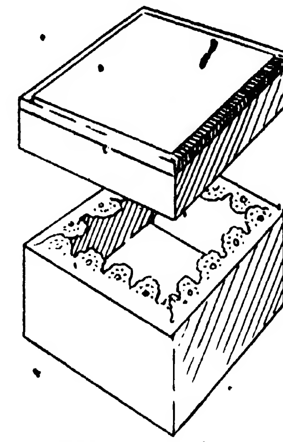


Diagram 5

the reel of paper, and will also insert a paper lace frill such as is used in chocolate and soap boxes. In addition, it provides for a gold or tinted

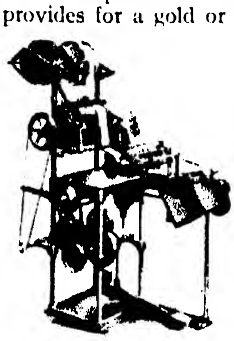


Fig. H.

edging at the box corners, as shown in Diagram 5. This is often required on collar and blouse boxes, and sometimes for soap, perfume, confectionery, etc.

The second category comprises all forms of "collapsible" box. This type has the primary advantages of packing and storing flat in one piece, ready for instant use. Collapsible boxes serve extensively for packing medicine bottles and pharmaceutical supplies generally, collapsible tubes, medical dressings, confectionery, flaked soap, cereal foods, starch, cakes, etc. They afford less protection to their contents than do rigid boxes, and the above stated advantages can be obtained to a limited extent with the latter by shipping the finished blanks in bulk to the user, who is provided with wire stitching machines only, and can thus make up his rigid boxes as required on the spot.

The simplest form of collapsible box is shown below, and it is from this that the many varieties met with have been evolved.

For making such boxes, only three machines are required, viz., the rotary cutting and creasing machine (I), for preparing the blank (Diagram 7) from the sheet of thin board; the folding box cutter (K), which can be supplied with heads for making the standard

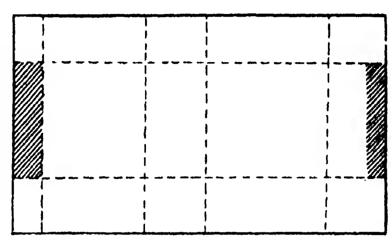
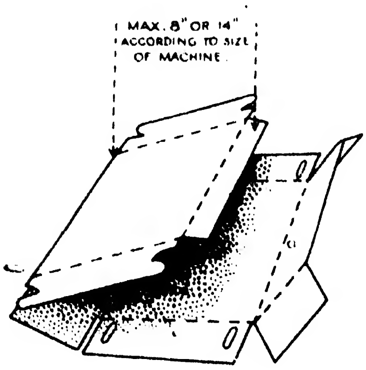


Diagram 7

or any other kind of cuts; and the folding box stitcher (L), for stitching up the single seam shaded on Diagram 7.

In the latter machine the boxes are fed continuously through the anvil.



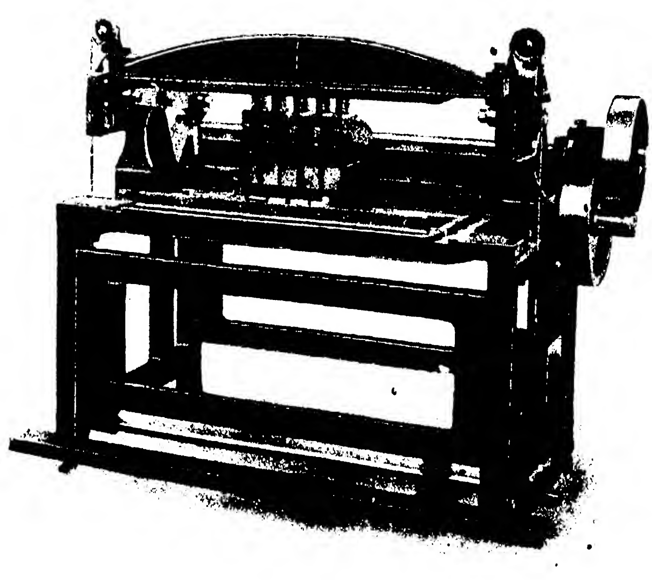


Fig. K.

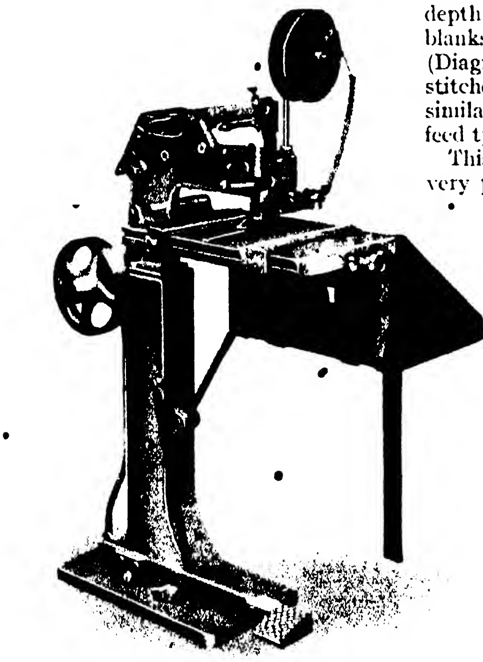


Fig. L.

The third category comprises "shipping containers" of large size. Many of these are made from double lined corrugated board, which, besides being both light and cheap, is very strong, and by reason of the air spaces between corrugations, affords a large measure of protection to the goods. These corrugated board containers are usually made collapsible, in which case they are prepared on a rotary cutting machine of large width, sometimes over 100 inches, generally similar in construction to Fig. A.

The board is then creased in a machine of the rotary scorer type, by means of the pressure of a blunt wheel pressing the board against a steel roller. When the large blanks are thus prepared, they are passed to a heavy slotting machine (Fig. M), capable of making cuts up to 13 inches deep, and cutting a corner to the same depth. On leaving this machine, the blanks may be of the form shown (Diagram 8A), and they are then stitched on a machine generally similar to Fig. L, but of the variable feed type, and in a larger size.

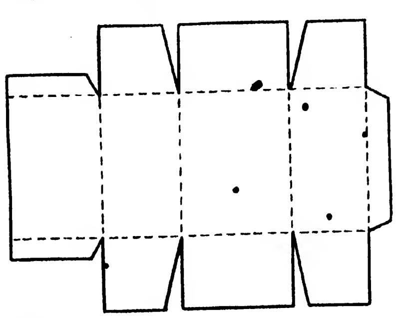
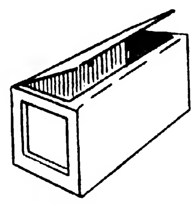


Diagram 8a

This form of shipping container is very popular in the U.S.A. A more common type in Great Britain is the rigid wholesale container built up of solid fibre board with wood end frames to reinforce it (Diagram 8). The plant necessary for this type is less expensive, though the material used costs more, as cheap quality boards are rarely, if ever, used. The cases are, of course, stronger than the corrugated board variety.



Finished Container

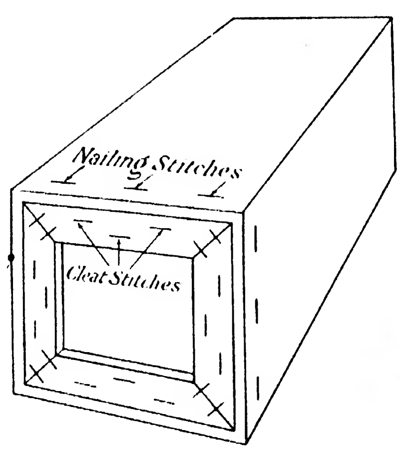


Diagram 8

The fibre (or leather) board (Diagram 9) is prepared in three pieces, one piece each for the ends, and a single piece bent to form the two sides top and bottom. The whole of this work can be done on a rotary cutting and bending machine, similar in general appearance to Fig. A.

The next process is to fasten mitred wooden cleats to the end pieces by wire stitching, and this is done upon a cleat stitching machine (Fig. N).

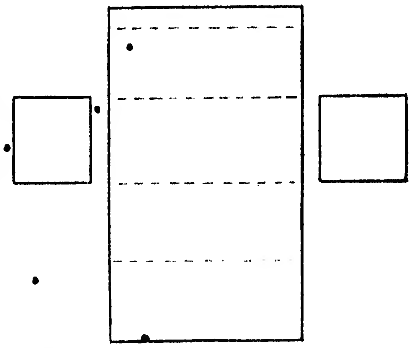


Diagram 9

This machine will stitch wood up to one inch in thickness without difficulty. When the ends are thus completed, the main piece of board is set up round them, and either stitched or nailed to the edges of the wood cleats. The lid flap is left open until it is desired to seal the container after filling. It is then either stitched along its front edge to the small flap provided, or adhered thereto with silicate of soda or some similar preparation. The edges of the lid are nailed or stitched to the cleats, and the resultant case is virtually pilferproof.

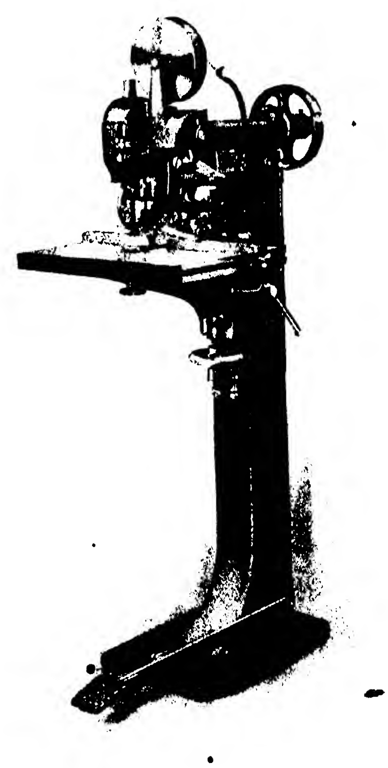


Fig. N.

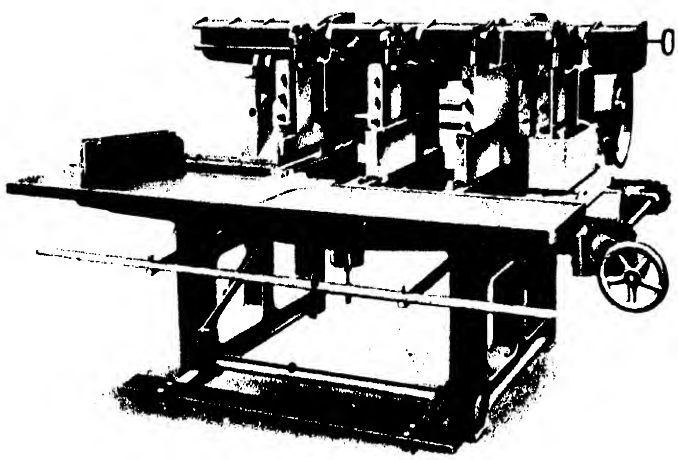


FIG. M.

A fuller description of these processes is to be found in any of the standard text-books on boxmaking, such as "How Paper Boxes are Made," published by The Shears Publishing Coy., Lafayette, Indiana, U.S.A., or "The Manufacture of Paper Containers," published by The Verstone Publishing Coy., 29 Ludgate Hill, E.C. Full details of machinery will be found in the catalogues of Messrs. Vickers Limited, Erith, Kent, illustrations of whose machines have been used to illustrate the present article.

A Brief Survey of Industrial India

(*Continued from page* 432).

BEFORE we turn to consider the industrial side of Indian commercial life, and its progress during recent years, reference must be made to two other sources of potential wealth—her forests and her fisheries. In both of these enterprises like so many others in India—a great expansion is possible. It is impossible to overestimate the importance of India's timber resources, especially at a time like the present, when the whole world is suffering from a shortage of timber—partly due to the heavy demands of the war, and partly due to the wanton destruction that has, through ignorance or indifference, been carried on in every timber-producing country of the world. In Australia, for instance, it was recently stated that over 600,000,000 tons of timber had been lost to the country through ruthless destruction. The forest lands of India cover an area of over 250,000 square miles—more than one-fifth of the total area of India, and an area twice the size of the British Isles,—yet so far only 100,000 square miles have been brought under regular management, systematic conservation, and scientific working. The Indian Forest Department has done good work in connection with the scientific aspect of forestry, and in preventing, to some degree, at any rate, the wholesale and wanton destruction of valuable timber, but up to now the commercial side of the industry has been, to a very large extent, overlooked, and neglected. Despite this fact, however, and despite the half-hearted method of working, the Indian forests are a source of considerable profit to the State, and yielded in 1917-18 a net revenue of rather more than 1.25 million pounds sterling.

The annual average production of timber and firewood during the five years 1915 to 1919 was 88,097,931 cubic feet, and 209,505,417 cubic feet respectively, but the authorities themselves declare that these amounts could easily have been doubled—perhaps trebled—had more intensive and systematic forest management been employed. But instead of attempting to increase production, India imported in 1918-19 no less than 35,750 tons, which quantity was increased in the following year to 68,036 tons. In 1920-21 the quantity imported was 62,582 tons. A very large amount of the imported timber has come from Japan, though it is a well-recognised fact in the trade that Japanese timber is inferior to Indian, and there is plenty of better quality timber in the Himalayas if only it could be utilised.

Forest products are classified under two headings—*Major Products*, which include timber useful for commercial purposes and firewood, and *Minor Products*, including such forest productions as lac, oilseeds, drugs, etc. The Indian forests contain an immense variety of trees, the Forest Department having already catalogued over 2,500 distinct species, and it is stated that probably another 2,500 await classification. Outside India, and, in fact, in many parts of India itself—the densest ignorance prevails regarding her timber resources, and in Great Britain the general opinion, until quite recently, was that India possessed only four kinds of wood—teak, satinwood, rosewood, and ebony. If the Forest Department is to keep abreast with the needs of the time, and develop its resources, and so secure an immense revenue, it must undertake some properly organised publicity work, whereby both countries may be made aware of what India possesses.

A step in the right direction in this connection was the acceptance by the Government of India of the Board of Trade's invitation to participate in the British Empire Timber Exhibition, which was held in London in July, 1920. Considerable attention is being devoted to the problems of extraction and utilisation, and in the Madras Presidency, and also in the United Provinces, "Forest Utilisation Officers" have been appointed. A scheme for the formation of a cadre of forest engineers has also been sanctioned, under which a regular service of engineers is contemplated. These are healthy indications that India is beginning to wake up and utilise, to a far greater extent and in a more scientific and economical manner, the vast stores of undeveloped wealth that her forests contain. An examination of the profits derived from the working of the Indian forests shows that during the last fifty years the increase has been nearly tenfold. With increased attention from Government, there will come increased assets and greater prosperity, and the inception and development of many forest industries. Among the most important of these industries is the resin industry, the chief centres of which are in the United Provinces and the Punjab. This industry, as is pointed out in official publications, is very largely due to the economic conditions created by the war, for the reduction in direct imports of American turpentine gave it an impetus which it is hoped will have permanent results. For the development of this industry there is certainly a very great scope. There is no reason why the ultimate production of Indian turpentine should not amount to over 1½ million gallons. A French manufacturing plant, modified to suit Indian conditions, has been installed in the Punjab, and a resin distillery erected in the United Provinces which will largely increase the total output. During the year 1917-18, 46,000 cwt. of resin, and nearly 140,000 gallons of turpentine, were produced, as compared with 44,000 cwt. and 130,000 gallons, respectively, in the previous year.

The paper industry also presents excellent prospects for development. The annual consumption of paper and paste-board in India amounts to over 75,000 tons, but at present two-thirds of this quantity is imported. There is no reason why this state of affairs should continue. The forest areas contain enormous supplies of bamboo and elephant grass, which could be utilised for the manufacture of all the paper and paste-board required for local needs.

The Lac Industry

Three and a half years ago a Committee of commercial men and forest officers sat at Dehra Dun to consider steps for developing the lac industry, and, as a result of their report, two expert officers have been appointed, one to deal with the sylvicultural and the other with the commercial side of the question. These and other new enterprises connected with the forest industry necessitate the expenditure of considerable sums of money, and between £20,000 and £25,000 is yearly spent under this heading. This, however, is not sufficient. To quote from the official Report of Indian Progress, issued in 1920: "Before the forest industries of India can be established upon a sound basis, there is need of expert investigation upon a more extensive scale than has hitherto been possible."

The present time is particularly opportune for the inception of a bolder and more scientific policy as regards India's forest products, for owing to the shortage of timber, not only in Great Britain, but in other countries also, special attention is being directed to the discovery of new sources of supply, and in this search India has not been overlooked. It was pointed out in a lecture last year in London that India posessses many valuable timbers which have been used in England in modern buildings, both for ordinary and decorative work, with most satisfactory results. It should be noticed, however, that though the Indian forests contain such a large variety of species, the percentage of timber-yielding trees is very low, being barely five per cent., but taking into account the vast extent of the forest lands, this low percentage need cause no undue alarm as to failure of supplies, provided ordinary care is taken, and conservation adopted on scientific lines. There is ample scope for development on a very large scale, without in the slightest degree depleting the supply.

Timber Industry

What the Indian timber industry needs is well-organised, efficient publicity work, to let the outside world know what it possesses, and what it is capable of supplying. Once this is known, there need be no fear of the future.

While for years attention has been increasingly given to the development of India's forest lands, it is only comparatively recently that any attention has been directed to another important and lucrative source of revenue and employment, viz., the fishing industry. In towns and villages within reasonable reach of the coast, the quantity of fish consumed by both Europeans and Indians is considerable, and, given cheaper and better transport facilities, there is no doubt that this quantity would be very greatly increased, but at present the dearness and the irregular supply is a cause of very general complaint, and a very serious handicap to the development of the industry. The report of the Indian Industrial Commission, however, affords striking evidence of the immense future which awaits a more active interest and development in this sphere. The attempt to improve and set the industry upon a better footing is beset with special difficulties, for the fishermen are usually of low caste, ignorant, uneducated, and idle, and content with a very low standard of comfort. They are usually, too, the ignorant victims of the middlemen, who selfishly and relentlessly exploit them, and whose exactions not only lessen the supply of fish, but add greatly to its cost. The sooner some scheme is evolved either to entirely abolish the middleman, or to bring him directly under some efficient authority capable of inflicting just punishment for unjust extortion, the sooner will the Indian fishery industry develop into a valuable national source of revenue. In Bengal, even under the existing unsatisfactory conditions, the importance of the fish trade may be gathered from the fact that during the year 1918-19 more than 11,000 tons of fish were caught and sent to different parts of the Province. At present there is only one Government Department for Bengal and Bihar and Orissa, with a totally inadequate staff, and until this state of things is altered, much improvement cannot be expected. The best that can be said regarding the fresh water fisheries in Bengal is that at present they are absolute failures, owing to the methods employed in working them, and unless other methods are used to prevent the depletion that is taking place, this industry will soon cease to exist. Such a thing as a "closed

season" is unknown, and continuous and ruthless fishing is carried on all the year round, immature fish being destroyed in large numbers, and even the fry and spawn are likewise destroyed. No wonder the demand far exceeds the supply, and the present serious position calls for the immediate attention of the authorities, and the putting into force of strong measures of protection to ensure the industry being saved from destruction. A step has already been taken by appointing district fishery officers, whose duty it shall be to explain the position to the people, and try to arouse in them some realisation of the harm which is being done, and of the danger threatening the industry.

In the Presidency of Madras the fishing industry is in a much more satisfactory condition, and over 250 small fish-oil factories have been established along the coast, mostly by the fishermen themselves. In 1919, fish-oil to the value of nearly £7,000, and fish guano to the value of nearly £30,000, were exported from the West coast of the Madras Presidency. A fish cannery, equipped with modern plant, has also been started, as the prospects for the canned-fish industry are considered very favourable. But in Madras, ignorance on the part of the fishermen is a serious hindrance in the development of the industry, and a step has been taken in this Presidency that might with very great advantage be followed in other parts of India, in the introduction of an educational scheme, by means of which specialised primary education shall be given to the fisher community. There exists enormous possibilities in connection with the fisheries of India, but their development upon a scale that will make them revenue producing and a valuable financial asset, can best be secured by first of all educating those employed in these industries, and thus arresting the destruction and waste that is now taking place.

The Grouping of British Railways

(*Continued from page 506*)

Both traders and the public will also gain in the long run by reason of the fact that each of the great new companies will inevitably appoint development agents to move up and down the country to discuss transport problems with interested parties. There will accordingly be a greater feeling of amity engendered, and this will be all to the good. In Great Britain, the attitude of the traders has hitherto been that they wished the railways to move their traffic in accordance with the requirements of the traders, but this is not always—and, in fact, rarely—the most advantageous for all parties. By means of an energetic campaign of propaganda work conducted by these development agents, it should, however, be relatively simple to prove to the traders that it is directly to their interest to co-operate with the railway companies, and thus secure the advantage of lower rates. The tendency, though it has only been a tendency, towards a closer relationship between traders and railways, has been manifested recently, and if, by reason of the new grouping arrangements, real co-operation can be secured, a great step forward will have been taken.

The formation of the principal railway systems of Great Britain into four huge systems is a problem of the first magnitude that has been faced, and admirably overcome, by all concerned. To deal at all adequately with the many aspects of the grouping problem, I should require quite a long series of articles of this length, but it may be that the brief treatment of the subject herein will at least give a bald idea of the developments. Both India and other countries may gain very much from a close contemplation of the manner in which the various difficulties—and they are many—are overcome in Great Britain, for excepting the complete nationalisation of railways in any one country, it seems to me that the inevitable tendency will be towards the aggregation of railway power in the hands of a few large units.

Time alone will show whether the drastic reorganisation of British railways has been the success its sponsors expect, but there does not seem any reason why, in the hands of competent administrators, the new systems should not be able to secure economies and to give better service to the community than was possible under the old methods. One thing is certain. The new companies just commencing to function will be wise to move warily. One of them has already announced that its development towards a complete merging will be a gradual one, and this seems a wise policy. To attempt by a stroke of the pen to immerse the varying methods and policies of several administrations into a cohesive plan would be futile. But I think it can be left to the four super-general-managers who have the responsibility for the new developments on their competent shoulders to see to it that adequate steps are taken to guard against undue haste. Many questions bristling with difficulties have to be faced: questions of organisation, questions of policy, staff questions, and so on, and all these in the flux of time will doubtless be smoothed out and brought into correct relationship with others.

The new railway era in Great Britain has commenced, and the grouping system is on its trial. If it succeeds, it will be a wonderful tribute to the foresight of its inventor, Sir Eric Geddes. If it fails, the only alternative is nationalisation, and, from British experience, that betokens the worst of all possible remedies, if it is not worse than the disease.

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

Low Temperature Carbonisation (xi)

(THE "CARBOCOAL" PROCESS)

BY DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min.E., Mem. Am. Soc. M.E., A.I.Mech.E., etc.

THE "Carbocoal" process is the invention of Mr. Charles H. Smith, of New York, and is owned by Messrs. The International Coal Products Corporation, of New York, U.S.A. The process consists of three distinct operations, as follows:—

(1) Primary carbonisation, that is carbonisation of the roughly pulverised raw coal for 2-3 hours at about 1,400 deg. F. (760 deg. C.) in horizontal retorts by external heating, through which the coal travels continuously, the gaseous and volatile products being separated as usual.

(2) Briquetting the residual fuel with pitch as a binder.

(3) Secondary carbonisation of the resulting briquettes for 8 hours at a comparatively high temperature of 1,800 deg. F. (980 deg. C.) in externally heated inclined gasworks retort, and separation of the further amount of gaseous and volatile products. The residual carbonised briquettes are then the finished smokeless fuel "Carbocoal."

Early in 1915 a large experimental plant, with an ultimate capacity of 100 tons of coal per 24 hours, was erected at Irvington, New Jersey, U.S.A., and this plant was run continuously for 3 years. During this time both large and small scale tests were carried out with the "Carbocal" process from May, 1915, to June, 1921, with coals from all over the world, over 125 different varieties being examined, including representative coals from Brazil, British Columbia, Canada, Chili, France, and Great Britain, in addition, of course, to the United States, and it is claimed that in every case the "Carbocoal" process was suitable of application, which also applied to a large number of lignites examined.

Capacity of Plant

With the extensive knowledge obtained on this plant a very large installation was then erected at South Clinchfield, in Virginia, on a site adjoining the Carolina, Clinchfield and Ohio Railway, with a capacity of 400 tons of raw coal per 24 hours, the largest plant in the world devoted solely to low temperature carbonisation. This plant, which is illustrated in Figs. 1, 2, 3, 4, was started up in July, 1920, and is on the latest and most modern lines, the whole process being continuous, and labour reduced to a minimum. The coal used is mostly the local Clinchfield coal, and the plant was in continuous operation from June, 1920, to the summer of 1921. This large-scale running has resulted in numerous practical difficulties being encountered, particularly in the way of wear and tear at certain portions of the plant. The plant was then shut down, so that these problems could be solved, and we understand that as the result of continuous work since the beginning of 1922, most of these have now been cleared up, and the plant is being altered accordingly, so that it will be started up again on full output very shortly.

As regards the general methods of working, the coal—as it arrives on the plant in railway cars—is dumped into a low level hopper, and from here taken by an apron conveyor to a crusher and reduced to ⅜ in. to ¾ in. size. The crushed coal is then conveyed by bucket elevators to the top of the main building, and distributed by conveyors to the storage bins supplying directly the primary retorts. If desired, the coal may also be washed either before or after crushing.

The primary retorts are long, stationary, horizontal cylinders, 18 ft. in length, and heart-shaped in cross section, built up of tongue and grooved blocks of carborundum with asbestos packed joints, carborundum being used because of its valuable resistant properties to wear and tear, and also its heat conductivity. The end walls are of cast iron, lined with firebrick, and support down the full length in the middle of the retort two longitudinal propeller shafts 12 in. in diameter, which are driven by suitable gearing, and are fitted with paddles of 2 ft. 3 in. radius, the clearance with the sides of the retort being about ⅜ in. The speed of revolution of these driving shafts is very small, about 1/12 revolutions per minute, and the power required is trifling, less than 2 b.h.p. The roughly pulverised coal from the retort storage bins falls into a hopper in front of the retort, which discharges the coal continuously into the retort, being under easy adjustment. The revolving paddles then convey the coal along the full length of the stationary retort whilst it is being carbonised, and at the same time thoroughly mixed and agitated, the retort being kept about one-third full of material. In this way the carbonisation is stated to be very even, and any exact degree of carbonisation can be obtained by altering the speed of revolution of the paddle

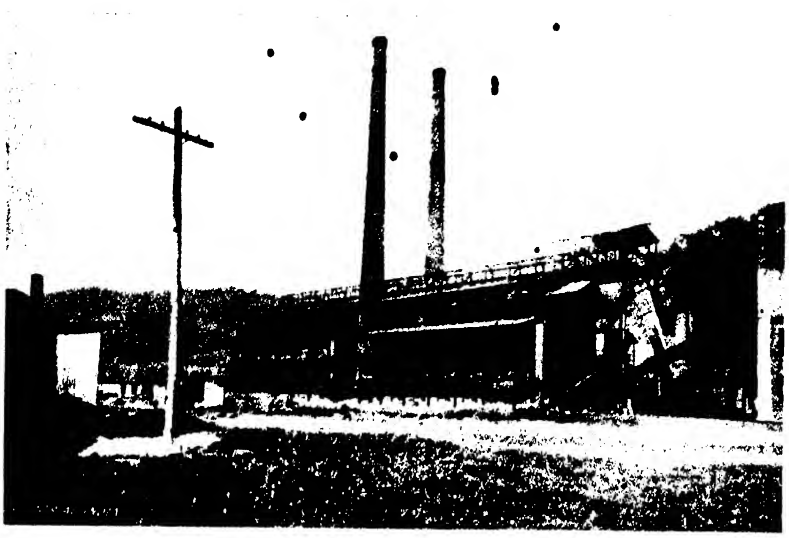
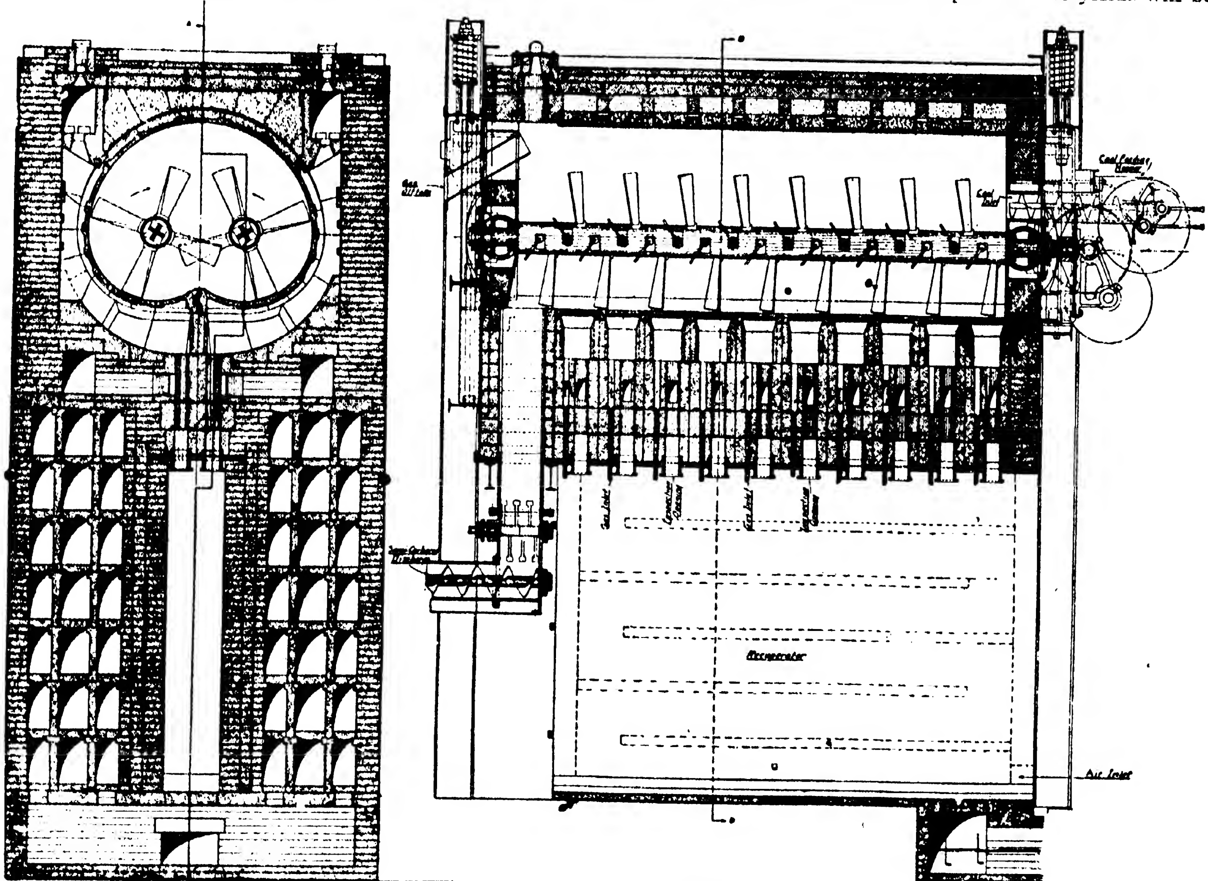


Fig. 2. Primary Retort Building

conveyors and the coal feed mechanism. Usually the temperature maintained is about 1,400 deg. F. (760 deg. C.), corresponding to 850-950 deg. F. (455-510 deg. C.) in the gas space of the retort, and the duration of the carbonisation 2 to 3 hours, this being the time taken for the coal to complete the travel through the retort, the throughput being approximately 1 ton per hour. The retort is heated externally by means of the stripped gas evolved during the process, or any other convenient gaseous fuel, the combustion chambers being obtained on the modern recuperative principle, the incoming cold air for combustion being heated by the hot exit gases on the way to the chimney.

The carbonised product, a soft, friable mass, known as "Semi-Carbocoal," is discharged continuously from the ends of the retort into a vertical discharge chute, containing at the bottom two revolving beaters, below which is a pair of screws, working in a water-cooled pipe with upturned mouth, so that the material forms a seal for the gas. The "Semi-Carbocoal" is then carried on conveyor belts to ball mills, ground, and stored in "Semi-Carbocoal" bunkers above the briquette house. The gas evolved passes into a foul gas main of the usual design *en route* to the by-product plant, the final stripped gas -as already stated—being returned to heat the plant. The yields will be



INDUSTRIAL INDIA

SECTIONAL VIEW OF PRIMARY RETORT USED IN MANUFACTURE OF CARBOCOAL.

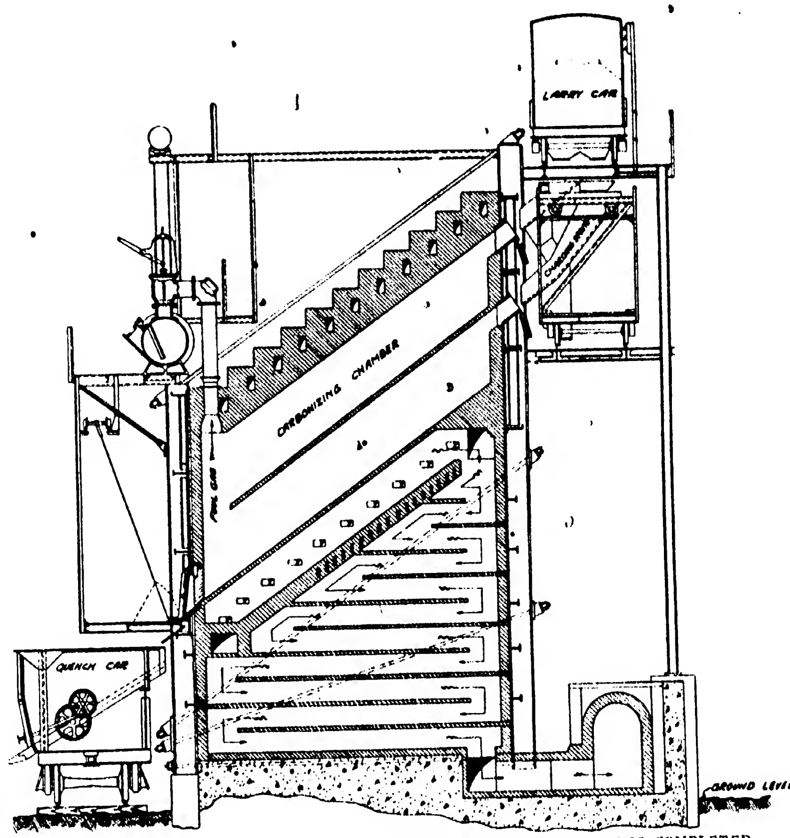
discussed later, but it may be stated here that "Semi-Carbocoal" contains 8-10 per cent. volatile matter when prepared from a 35 per cent. volatile coal. The material is then further crushed to all pass through ⅛ in. mesh, mixed with 8-10 per cent. pitch from the by-product plant, taken to a "fluxer," mixed thoroughly with the aid of steam heating, and delivered hot to the briquetting presses.

Briquetting Press

The presses used are of the roll type, the briquettes being turned out in any size from 1-5 oz. each, but generally as "eggs" of 3 oz. They are discharged continuously on to a moving chain conveyor, and taken as "raw briquettes," containing about 15 per cent. volatile matter, to overhead storage bunkers at the secondary retort, being cooled on the way, and delivered finally to the secondary retorts by means of small wagons.

Secondary Retorts

The secondary retorts are modified fireclay inclined gas retorts, of a rectangular section instead of the usual D, each section having three compartments, of two carbonisation chambers. The time of carbonisation is 8 hours, and the retorts are simply charged through the upper end by means of small conveyor cars, with about 9 tons of raw briquettes. The temperature is approximately 1,800 deg. F. (980 deg. C.), that is essentially high temperature carbonisation, and the gaseous and volatile products, which contain a large amount of ammonia, are passed into a hydraulic main, as usual, and discharged to the by-product plant. The heating, as before, is by means of stripped gas or any other convenient gaseous fuel, and the combustion chambers are on the modern efficient recuperative principle. During this secondary high temperature carbonisation, the pitch binder is decomposed along with most of the remaining volatile matter in the coal of the raw coal briquettes, which shrink considerably in volume, but without any distortion in shape. The finished briquette, "Carbocoal," is extremely hard, with 3-4 per cent. volatile matter, and on discharging from the secondary retorts is quenched with water like coke, and delivered to conveyor trucks for transference to the storage dump. The Clinchfield



SECTION OF SECONDARY RETORT IN WHICH CARBOCOAL PROCESS IS COMPLETED

coal, mostly used, has the following average composition :—

(1) Fixed carbon	...	57%
(2) Volatile matter	...	35%
(3) Ash	...	7%
(4) Water ...	...	1%
		100%

As a result of the carbonisation of many thousands of tons of this coal, the yield by the "Smith Carbocoal" process from 1 ton of raw coal is found to be as follows :—

1. GAS.

(*a*) 5,600 cubic feet from the primary retort (650-700 B.Th.U. per cubic foot).

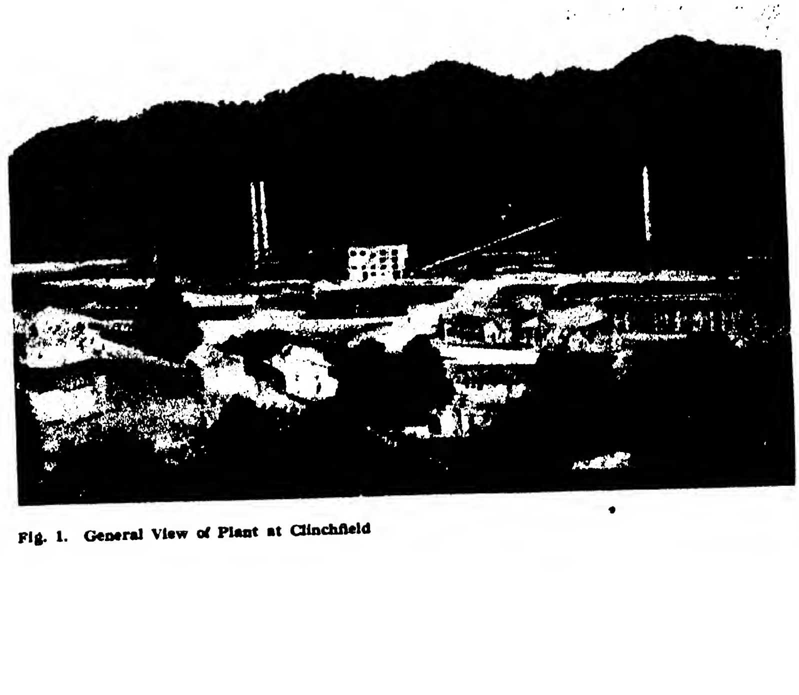


Fig. 1. General View of Plant at Clinchfield

(*b*) 4,480 cubic feet from the secondary retort (300-400 B.Th.U. per cubic foot).

Total, 10,080 cubic feet.

After stripping, most of this gas is used for heating the primary and secondary retorts, and in the by product plant.

2. TAR.

(*a*) 21.0 gallons from primary retorts.

(*b*) 5.0 gallons from secondary retorts.

Total, 26.0 gallons.

This is the average figure for normal good working, although due to minor defects in the plant, now, as already stated, well on the way to being remedied, the actual yield for the whole of 1921 was 23.3 gallons. This tar, on rectification, gives about 10 gallons of high-grade oils, free from water, and 16 gallons of pitch.

3. SULPHATE OF AMMONIA.

When the plant is in good working order, the yield of sulphate of ammonia is about 20 lb. per ton, but this has been often reduced because of leakage.

4. "CARBOCOAL."

14½ cwt. "Carbocoal" briquettes, which have had put into them, of course, about 1½ cwt. of pitch, most of which is, however, obtained from the process. These briquettes are, of course, absolutely smokeless, free burning, and give a high emission of radiant heat, with practically no dust and liability to spontaneous combustion, and they sell in America on the same basis as anthracite, over 70,000 tons having been disposed of at prices from $7 to $12 (29/- to 50/-) per ton of 2,000 lb. at the plant. They are suitable for every purpose for which coal is used, household, locomotive, bunker and general steam generation purposes, and it is claimed—because of their great hardness—that they will in many cases replace metallurgical coke, the crushing strain at 2,550 deg. F. (1,400 deg. C.) being 943 lb., and they contain about 94 per cent. of the original heat of the coal.

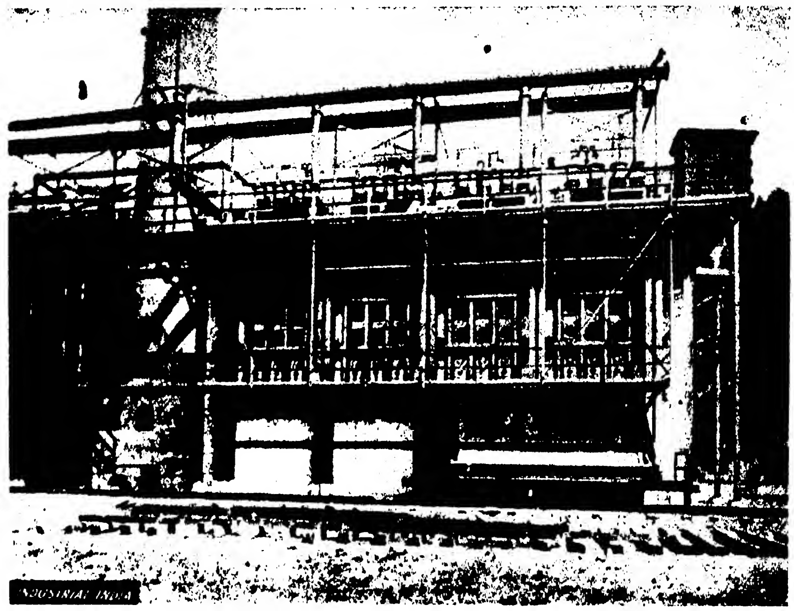


Fig 3. Secondary Retort Building

United States Navy tests show an evaporation of 9.09 lb. water from and at 212 deg. F. per 1 lb. of "Carbocoal," as compared with 9.59 lb. for the original coal, whilst the Fosdick Machine Tool Co., in tests on a horizontal tubular boiler, found that coal of 14,120 B.Th.U. evaporated 6.59 lb. water, whilst "Carbocoal" of 12,470 B.Th.U. gave a figure of 7.34 lb

As already stated, the plant will very shortly be started up again with many minor improvements based on the very valuable and unique experience gained of extensive large-scale low temperature carbonisation, and I have to express my very best thanks to Mr. Harry A. Curtis, the general manager of the plant, for his kindness in furnishing me much of the information contained in this article.

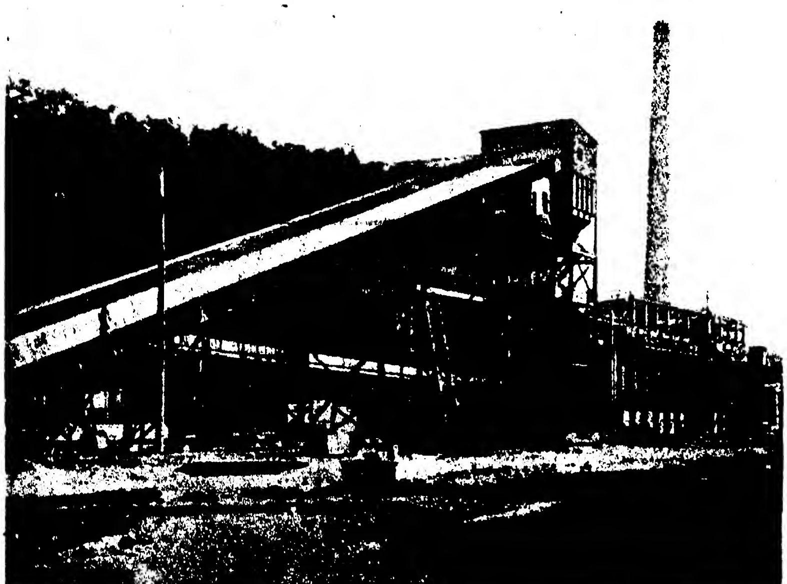


Fig 4. Conveyor and Secondary Retort Building

The Production Engineer

A paper presented to the Institution of Production Engineers by
Mr. H. E. Honer, a Vice-President and Member of Council, M.I.P.E.

THE future of the engineering world is a question frequently discussed in industrial circles, and is undoubtedly one that assumes greater importance in financial, commercial, and family life as science moves onward, gaining new knowledge of the elements and of chemical and physical processes.

It is instructive for a moment to review the past, and to see how, in the earliest times, it was necessary for the peoples, in order to maintain life, to make crude implements for their use in the fields and in hunting and fishing. These primitive tools, etc., were also the subject of barter amongst neighbouring tribes, and in later years were exchanged for the merchandise of other countries, until ultimately certain tribes or nations became noted for a particular article or class of goods. The demand then grew until the hand-made article could not be produced in sufficient quantities to meet requirements, so that machines were devised to obtain the necessary output, until to-day we find huge factories engaged in the manufacture of one component or group of components.

This process of evolution has, without doubt, enabled all classes, rich and poor alike, to enjoy a fuller life according to their means. To take only one instance of the remarkable number of articles manufactured for use in the home, the containers for a great variety of foodstuffs may be mentioned. These alone have provided the means by which we can enjoy hitherto unknown products of the Empire, and when it is considered that millions of tins are used annually it must be admitted that the rapidity with which these containers are made is largely responsible for the low price at which such foodstuffs can be obtained.

Electric fittings, cheap watches, clocks and bicycles, and many other items may be added to the list of commodities which have been brought within the reach of those in humble circumstances by means of specialised production and the use of high-class and highly efficient machine equipment. To those in more affluent circumstances, the motor car, motor cycle, etc., have been brought within easy reach by the use of special machines, jigs and fixtures, etc., and operators trained to perform one operation only on a highly efficient basis. The methods so adopted to obtain these results have been introduced by those who, however designated, can be recognised as true production engineers.

In forming a true conception of the status and duties of a production engineer, the following illustration will, I hope, prove helpful.

Suppose for the moment that a financed corporation desires to invest its capital. It seeks, through its particular channels, information as to the best means of investment, and the manufacture of a certain article is decided upon. Experimental work is then carried out, data is collected, and designs are made and approved. The corporation then proceeds to obtain the services of a production engineer and of a works manager, who, after receiving instructions and the necessary information, would arrange the layout of the factory buildings with a view to obviating loss of time in the transport of materials or partly finished components, etc., from one department to another. Having completed the layout, they would submit it to the directors, who, after careful consideration and constructive criticism, would invite tenders from firms interested in that particular class of building. During the period of construction the production engineer would obtain estimates from makers of various types of machine tools and other equipment for the tool-room and factory generally.

In the meantime the drawing office staff would be arranging detailed drawings and allotting to each part a number. Prints would then be sent to the production engineer, who, in turn, would issue to the planning, jig and tool, and rate-fixing departments under his control the necessary copies with suggestions in each case. He would also give instructions as to which parts should be given preference, owing to operations on such parts taking a longer time to prepare or execute than those on other details, such precautions being essential to maintain the balance of production. After the operations on each part had been laid out in sequence, these, together with drawings of the jigs, tools, and gauges, would be sent to the works manager, who in turn would give orders to the tool-room to commence work on the jigs and tools. He would also arrange, according to the plans, the layout of the machines and equipment in readiness for the commencement of operations.

Assume now that the factory is in full swing. The production engineer is receiving from the bonus department particulars as to actual times taken on each operation; such times in each case are checked against those allowed by the rate-fixing department. Quantities passed as correct by the inspection department are checked, and should there be a number of parts scrapped through faulty machining, bad castings, or material, the production engineer would at once investigate to see if the methods laid down by the planning department were being carried out. Should this be in order, it would be his duty to find methods, if possible, to eliminate further risks of such defects in a subsequent batch of parts.

He would give consideration to the use of special machines, by which the operation or operations and the time spent on each would be reduced to the minimum; even on centre lathes, methods would be reduced to the simplest form. In a similar manner consideration would be given to the methods employed in every department of the factory. The foundry often presents opportunities for effecting economies by the use of moulding machines and other equipment, whilst frequently holes that are cored can be drilled at a very much lower cost. Cast bars or bushes will also be useful

in some cases to avoid the use of separate castings and simplify chucking in the machine shop.

The production engineer will also have opportunities for reducing time taken in the fitting or assembling departments by supplying accurately machined parts in predetermined quantities by the use of assembling fixtures, avoiding, wherever possible, filing and hand-fitting operations and by the arrangement of partial assemblies preparatory to the final assembly.

In effect it would be his duty to study each detail or part, from the design office through each department or operation, right up to the finished product. We have all experienced cases where the pattern shop make the pattern to suit their own ends, or where the foundry adopt methods that cause the machine or fitting shops considerable trouble, and one could go to considerable length giving instances of lack of organisation in this respect. It is, however, sufficient to know that there are but few instances where a production engineer could not be profitably employed.

With regard to costs, to enable the production engineer to discover discrepancies, comparative costs of each detail or part up to the completed article would be supplied to him by the cost department, and by the intelligent use of such figures he would be able to maintain a firm price, thereby rendering valuable service to the company.

No doubt some will take exception to the position and scope accorded to the production engineer in the foregoing illustration. As a further instructive example, therefore, the case of a large firm having interests akin to that of a parent company, or having branches in other parts of the country, may be considered. The employment of a production engineer under such circumstances would be attended with much success. His duties would be connected solely with production, and he would not be worried with matters outside that. It could therefore be reasonably expected that the expenses of his department would be many times covered by the economies that would be effected by his concentrated efforts.

Responsibilities

To deal with specific cases is, however, difficult, since every factory presents its own problems. In some factories the production engineer will be directly responsible to a board of directors, whilst in other cases he will be responsible to the managing director, and in others again to the general manager. Whatever his status may be, however, it cannot be denied that the production engineer carries out duties of the utmost importance, and, this being so, he should be given a position as one of the executive heads, and should have every consideration and assistance in carrying out his duties.

One cannot over-estimate the difficulties that a production engineer will encounter, particularly upon his introduction into a firm where old and antiquated methods have held sway. He will have many prejudices to overcome, much opposition, and many jealous individuals to win over. His character and temperament will perhaps be tested and tried to its very limits. He will of necessity be prepared to act with, and accept, suggestions with good grace from all those with whom he may come in contact.

Cost Reduction

Experience has proved that where a capable production engineer is employed, and has the co-operation of all concerned, the price per piece is considerably lower than in factories where such an organiser is not employed. His one aim is efficiency combined with minimum cost. By studied efforts, linking one department with another, etc., he will be able to effect economies that would not be possible under old-time methods.

The introduction of the principle of "one man one job" cannot fail to be of interest to the production engineer, since in many cases it is the basis of substantial economies. With certain exceptions, however, I believe that one of the ultimate effects of applying this principle will be a drastic revision of the present-day apprenticeship system. For instance, under better conditions it would no longer be necessary for a boy to serve for a period of five or six years as an apprentice. Instead, he would start on one of the simplest operations or machines, and by merit and ability would advance to the better-paid jobs. In effect this would encourage beginners to do their best, and would lead to the survival of the fittest.

Another effect of applying this principle is a tendency to reduce the number of skilled journeymen or tradesmen in industry. Whether this is desirable or otherwise is beyond the scope of this paper. Some will welcome such a change, some will deplore it, whilst others will seek to destroy the foundations on which such a system may be built. Whatever opinion we may hold, however, it is our duty to the Empire to gain for it by our abilities pre-eminence in the manufacturing world. This object can only be achieved by supplying goods of high quality at a reasonable price, so that a demand will be created which will be sufficient to provide employment for all. It will thus be apparent that the production engineer fulfils a purpose of supreme importance if he is able to reduce manufacturing costs, and at the same time maintain quality. To devise and use labour-saving devices to the best advantage, therefore, to reduce handling charges and the cost of production of a part or an assembly, having due regard to quality, are the true functions of the production engineer.

Statements have been made to the effect that the production engineer must be a man of good education. This is obviously one of the first requirements, since he will at all times be called upon to give advice, to give a considered opinion on important points, to detect mistakes, to understand technical matters, and, in short, to be worthy of an executive position. To keep abreast of the times is to seek knowledge; to apply knowledge so gained usefully is the action of an educated mind. This leads to the important point that the foundation of this Institution was to give opportunities to keen men to increase their knowledge, to enlighten others on the difficulties of their own particular trade, and to point out the pitfalls that await the unwary. During the last session many papers on subjects of great interest and importance were presented, and no doubt there are those who have used the facts so gained to advantage in their own particular line of manufacture. This is generally beneficial to trade and to the good of the individual.

So far as the production engineer is concerned, I believe that this Institution is of the greatest importance to him. Through it he will obtain valuable information on many subjects, data that can be relied upon, and helpful suggestions to assist him in his own work. There have in the

past been few facilities available, except through the medium of text-books, technical journals and local societies, for the man who desires to obtain first-hand information, either on a practical matter or theoretical subjects. Text-books are frequently too concise or full of formulæ, or, as in the case of the lower class of technical journals, sometimes give, with natural leanings to their advertisers, details of where a certain line of machines might be used to advantage, ignorant of the fact that such machines are not suitable for the work. Therefore, it is my considered opinion that as the employment of production engineers becomes more general in the factories of this country, the true functions of this Institution will become more apparent, and that he, the production engineer, will turn to it to obtain such facts and information as he requires in his work.

Giving good service, as one has every reason to believe it will, it cannot fail to enlist members from the most capable men in this and other countries, and so build up an Institution that will be a power in the engineering world. This being so, it will be the duty of its members to reach and maintain as high a standard as possible.

In his paper last season the President stated that in his opinion the production engineer was born and not made. This is true, undoubtedly, of all engineers, and accordingly we, as an Institution, should give every encouragement to the young engineer who has marked ability. It should be our privilege to help him in every possible way, and to give him opportunities to study production methods, for we may be sure that as the trade becomes more scientific and specialisation more marked, it will be very necessary for one having the ambition to engage in the profession of a production engineer to have facilities offered him that will assist in fitting him for his task. Many here have learnt in the hard school of experience, but the future will demand specialised training for the official as well as for the worker. Accordingly it is for us to make this Institution the means by which we and those who follow us can receive assistance that will enable us to carry out our duties to the satisfaction of all concerned.

In conclusion it would, to my mind, be an advantage for a production engineer to study industrial psychology. It is not sufficient for him to get results without due regard being paid to fatigue. No worker, no matter what his occupation may be, can give good results if the operations on which he is engaged quickly tire him. To use an economic metaphor, there are two funds from which the human body can draw, either from capital or from interest. If it draws from capital it will go bankrupt; if it maintains its capital and draws from interest it will last a long time. Therefore it is not advisable to study minimum times only, but the time that is economically satisfactory. The intensive development of the productive capacity of a workshop bears a very definite relationship to the development of conditions which preserve and maintain the interest and concentration of the human element, whether directing, administrative, or manual, upon which, in the end, the finished product depends.

It is therefore to be hoped that we shall give such important matters as this earnest consideration, and, by so doing, gain the confidence and respect of all.

Oxy-Acetylene Cutting Machines

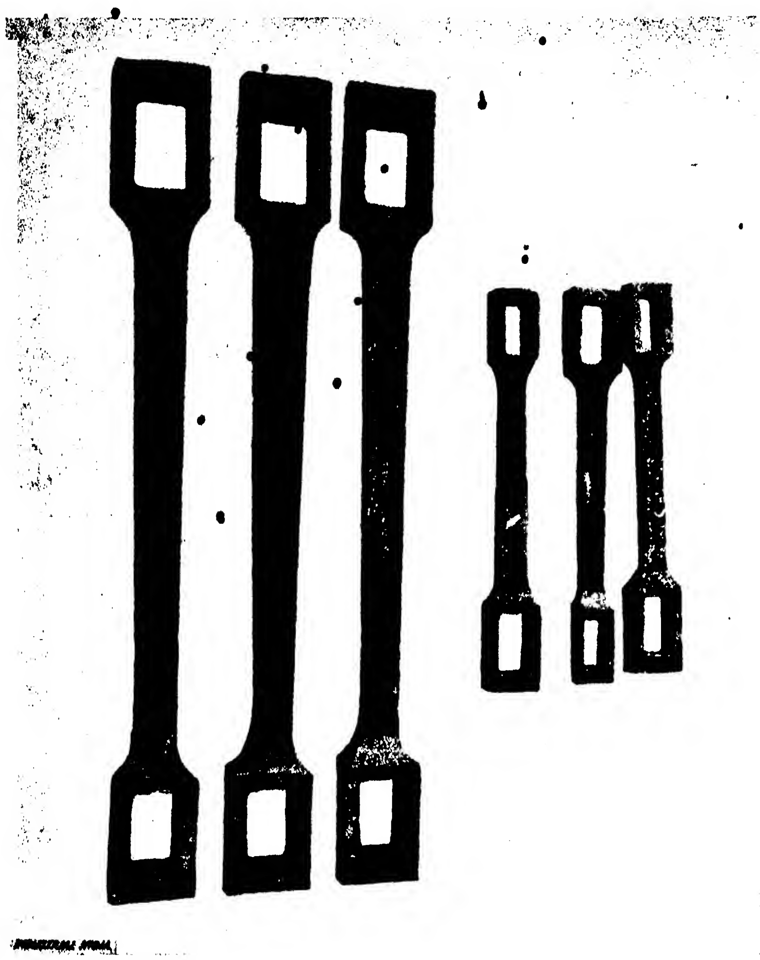
IN a paper read before the American Welding Society, at Chicago, in the Spring of 1922, Mr. Fred J. Maeurer gave some interesting facts concerning the cutting of steel by means of Airco-Davis oxy-acetylene cutting machines. The purpose of this article is to go over this matter for the benefit of our readers, and to give them a description of the machines, also to explain the operation of them, roughly outline the main construction features, and to show the advantages to be derived by replacing hand labour with mechanical means where such can be applied economically.

It is a mechanical age that we are at present so fortunate to be living in, and all around us we are constantly seeing evidence that engineers of the numerous professions are devoting considerable time, attention, and study towards improvements and new developments. In the manufacturing field this has been towards the introduction of new and better methods of production, with a big tendency to employ labour-saving machines.

Developments in the engineering field so far have shown conclusively that the human element plays an important part, and wherever it can be removed and machines substituted, a marked gain will be the result in increased production at lower labour costs. Electric power has been the means of ensuring the best and smoothest means of speed control, particularly where that power is controlled through motors connected to mechanical contrivances. With respect to cutting torches, it means that when electric motors are employed to operate the mechanism, smooth travel and uniform cutting speeds can be maintained with ease.

It has been proved that when hand cutting is employed on steel stock, the oxygen consumption of the torch is likely to be excessive, and not consistent with the work turned out; furthermore, the speed of cutting tends to be somewhat on the slow side, and accuracy and smoothness of cut not all that it is to be desired. These deficiencies can only be rectified by substituting machines for the human element.

The waste of oxygen seems to be the most important item to be taken into consideration, and the appointed executives are constantly on the look-out for up-to-date equipment to enable the welding operators or cutters



Connecting Rods showing ends cut out by the Oxygraph

to obtain the maximum production with the same, or even less, oxygen consumption than with hand methods commonly employed. Aside from the introduction of labour-saving machines, the manufacturers of oxy-acetylene cutting apparatus have been able to substantiate the claim that increased production can be got by insisting upon the operators abiding by the instructions for working the apparatus as supplied with the machines. It is a trait of most of us to follow the easiest course which presents itself. As applied to cutting apparatus, it seems to be to increase the oxygen pressure beyond that recommended by the manufacturer for a given size of tip, either inadvertently or, otherwise. It may be that it is thought possibly the manufacturers have been on the conservative side in statements in instructions, and that more pressure will accomplish better working conditions. As the manufacturer is the one who must cater to the trade, and make such improvements as will render the maximum service to his customers, it is to be expected that he should know more about his apparatus initially than anyone else. With this in view, the torch tips are designed each for a given purpose, to produce the maximum of heat efficiencies at the pressures stated for each type of torch. The type of torch and tip, and the correct working pressures, have been set as the result of a large number of experiments, not only in the laboratory, but actually as applied to commercial work in the field. Most companies have a service corps of experts whose business it is to work the industrial field, visiting manufacturing plants of all descriptions where equipment supplied by their principals is employed, and to give instructions as to the use and care of that apparatus. This also forms a means for disseminating the latest information as to improvements or new developments. It is recognised that this service is a great help towards getting operators out of ruts, and to give a man a fresh lease on his vocation. Unless the operator is particularly keen and energetic, and possesses a thirst for knowledge, he is not likely to be found always investigating on his own initiative the latest developments in the line of his choice.

One great source of trouble has been that the operator has a distinct tendency to employ for cutting a tip anywhere from two to four sizes larger than the thickness of the cut warrants, thus consuming considerably more oxygen and gas than would be the case had the correct tip been used. The larger tips are used, of course, because it makes the cutting easier. To overcome this waste, the service department take the same tool, same tip, use the same pressure that the operator happens to be using, and demonstrate that metal much thicker than they were cutting can actually be cut with that tip and pressure. It follows that a smaller tip and pressure would have served the purpose and accomplished the required result.

To overcome these difficulties it is necessary that there be close co-operation all round. Short courses in instructions, and demonstrations for the benefit of the operators, prove helpful to solve the trouble.

Scientists have worked out accurately exactly what can be expected in results by using various oxygen and acetylene pressures when employed for cutting. Mr. Maeurer states that he has in his possession a report from a prominent metallurgist showing that the most economical proportions of oxygen consumption to oxidised metal are one cubic foot of oxygen to point two two one pounds (.221) of steel, *i.e.*, for every cubic foot of oxygen put to use by the operator, he should be able to oxidise .221 pounds of steel without adding extra weight to the steel. The Airco-Davis Co. have carried out commercial tests to check these figures. The test period covered a long space of time. Half inch thickness of steel was used for the tests, and both hand cutting and machine cutting employed for comparison,

The test also covered the use of various sizes of tips at different pressures and speeds, with the idea of making the trials as complete as possible.

Five thousand (5,000) feet of ½ inch plate was first cut, which took 136 actual working hours. Three tips were used at different working pressures, and it was found the smaller tip gave the best results. The best cutting results were 393 linear feet cut in one day at an oxygen consumption of 565 cubic feet. The average speed of cutting worked out at 8.16 inches per minute, using 1.43 cubic feet of oxygen per linear foot of steel cut.

To illustrate the large part the human element plays in hand cutting, Mr. Maeurer states that on one of the days during the trial tests under the same and ideal working conditions, the same operator that reached the above figure made no better showing than 258 linear feet cut. For the remaining days his rate of cutting varied considerably, indicating that it is almost impossible for an operator to keep up a uniform speed of cutting days on end.

After the hand cutting tests were completed, attention was directed to machine cutting, with somewhat different results. To get accurate comparisons, the same thickness of plate, same sizes of tips, and lower oxygen pressures, were used. The plates cut were 12 feet in length. The speed reached with mechanical means for cutting was 18 inches per minute, at an oxygen consumption of 1½ cubic feet to each 18 inches of steel cut. The path made by the torch was ⅛ inch wide. To quote Mr. Maeurer: "As one square foot of steel plate ½ inch thick weighs 20 pounds, and dividing this into ⅛ inch strips, we find we have oxidised .21 pounds of steel with each cubic foot of oxygen consumed, which is mighty close to the figures submitted by the metallurgist. All the machine cuts were smooth and straight. Two thousand five hundred (2,500) linear feet were cut by the machine."

Several other tests were made on various thicknesses of metal, using larger tips and higher oxygen pressures, the results in all instances indicating that far greater speeds of cutting could be made on the machines over hand cutting at a considerable reduction in oxygen consumption.

It is pointed out that as a great amount of cutting is done in an emergency, it has been found difficult to convince the engineers at times of the waste of oxygen in hand cutting. To bring the point to their attention forcibly, it is necessary to perform some exceptionally good cutting in their presence.

The machines marketed by the Airco-Davis Co. comprise the Radiograph, the Pyrograph, the Comograph, and the Oxygraph. The Oxygraph machine will be described in the present article, and we hope to be able to cover the other types in a later issue of INDUSTRIAL INDIA.

The Oxygraph group consists of two distinct sizes, one designated as the 1A and the other as the No. 2. The 1A machine is designed to reduce the cut made to a size one-half of the size of the drawing or tracing followed, while the No. 2 machine, when in operation, produces a full-size cut of the template or tracing followed.

Fig. 1 illustrates the 1A machine set up, connected to supply cylinders, and adjusted ready for work. The photograph shows clearly that the eye-pieces of the connecting rod have already been completed. The pit below the stand is for the purposes of receiving waste metal and oxides produced as the results of cutting.

The general principle of construction of both the 1A and No. 2 machines is the same. The machine cutting torch is supported on a pantograph framework. On this frame is also mounted a small electric motor, which operates the feed gear. A knurled disc forms a driving wheel, which is geared through worm and spur gearing to the motor and mounted in a forked rest of one of the swiveled vertical members of the pantograph frame, leaving it free to be moved in any desired direction. From this combination of electrical and mechanical apparatus it will be seen that ample means are provided for moving the torch mechanically in any horizontal position. The rate of travel is uniform, and the speed is capable of being varied over a wide range.

On either side of the tracing disc tracer points are fixed. These are attached to the vertical swiveled parts in order to add to the ease of following the drawing.

The motor, which is designed for universal use, that is, for connection to either A.C. or D.C. source of power, is usually wound for some standard voltage such as 110 or 220 volts. The speed control is effected through the introduction of a field rheostat mounted next to the motor for convenience sake.

The driving disc makes contact with the tracing or template at all times, and when put into motion by the electric motor, revolves slowly along in the direction desired, swinging with it the pantograph frame and cutting torch. The direction of travel

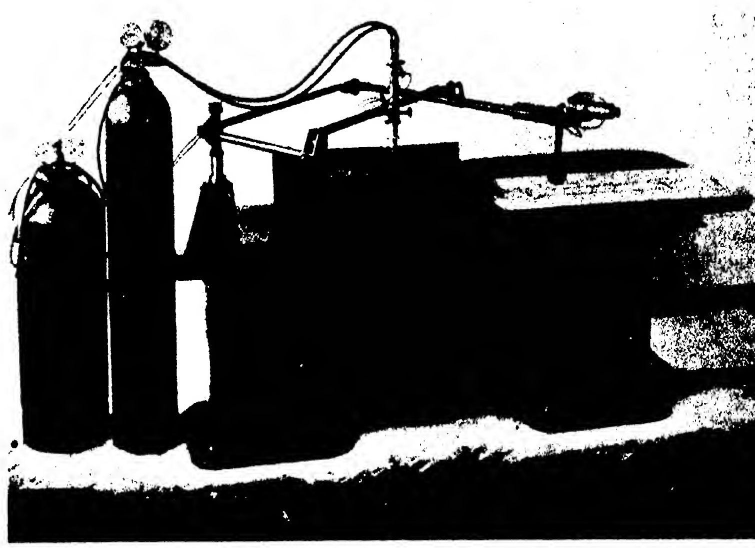
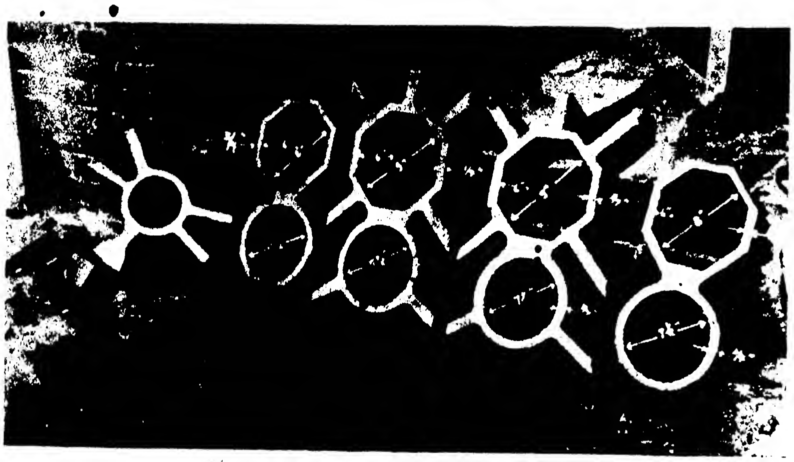


Fig. 1. No. 1a Oxygraph with drawing on table for reproducing small solid end connecting rod



Mast Bands cut from solid forgings with the Oxygraph

is determined by the position of the knurled feed disc with reference to the table and torch. A steady and uniform motion in any horizontal direction is provided by the feed mechanism.

When in operation, the cutting torch is guided by the operator working the upright post, turning it forward, backward, or sideways, as the case requires. This compares favourably with the control of an airplane by means of the joy-stick, as it is sometimes called. In this way the cutting torch is made to cut along the desired lines, producing a piece of work with the same outline as followed by the tracer wheel.

An allowance must be made for the width of the kerf left by the cutting torch. The kerf may work out at anything from $\frac{1}{16}$ in. to $\frac{3}{16}$ in. wide. The allowance can be made by adjusting the pointers. When the distance between the tracer points and the centre of the tracing wheel is set to equal the width of the kerf, it will be found when cutting that the cut is true to the outline drawing. The kerf allowance can also be reckoned by making track lines on the drawing on the outside of the outline at the distance it is necessary to allow for the kerf. The tracer wheel would then be run along the allowance line, and the pointer disregarded for straight runs and taken into consideration only when sharp corners have to be negotiated.

For jobs where it is desired to make only one or two reproductions, pencil drawings are sufficient, but for production work metal templates are recommended. The template recommended for straight line cutting is one having a groove forming a track for the tracer wheel.

The work table used with the 1A machine measures 36 × 36 inches. The surface covered by the torch when the largest permissible drawing is used and laid out on the table is 18 × 18 inches. Rectangular cuts larger than this can be made by arranging the work on a diagonal from corner to corner of the table. To obtain cuts larger than this, it is only necessary to extend the table by adding a drawing board of a suitable size.

The other photographs shown illustrate some of the classes of work to which the 1A Oxygraph can be adapted.

Miners' Electric Lamps

ELECTRIC safety lamps for miners are being used in ever-increasing numbers, due to the obvious advantages which they possess over oil lamps. The higher c.p. of the electric lamp ensures a greater output of coal, thus reducing working costs. It has also been proved that the electric lamp is cheaper in upkeep costs than the oil lamp.

The "Ceag" Miners' Supply Co. Ltd., of Barnsley, England, have supplied over 500,000 miners' electric safety lamps, and several "Ceag" electric lamp installations have now been working for oven ten years, and are still giving complete satisfaction.

The lamps manufactured are made at their Barnsley works, which are equipped with the most modern patterns of machinery for the rapid reproduction of accurate parts. All details of manufacture are made to gauges, and are interchangeable, with the result that accurate spare parts can be supplied immediately.

These lamps have several patented features, described below in detail, which ensure economical and safe working, these special features being exclusive to the "Ceag" lamp.

A further point of interest is that the "Ceag" lamp was awarded the first prize of £600 in the Home Office (International) Competition in 1912 for being the best designed and constructed safety lamp. Since that date great improvements have been made, and the "Ceag" is still claimed to be the most economical, reliable, and efficient lamp.

The Company have a research department, which investigates the possibilities of all new materials and methods of manufacture, ensuring the lamp always being maintained at the same high standard.

The "Ceag" pillarless electric lamp, the latest product of the Company, has been designed with a view to projecting an uninterrupted beam of increased candle-power over a wide arc.

Fig. 1 illustrates the lamp in front elevation, and Fig. 2 in side elevation, from which latter figure it can be seen that the lamp can be used for roof examination and like purposes.

The lamp consists of a standard miner's lamp, fitted with a special

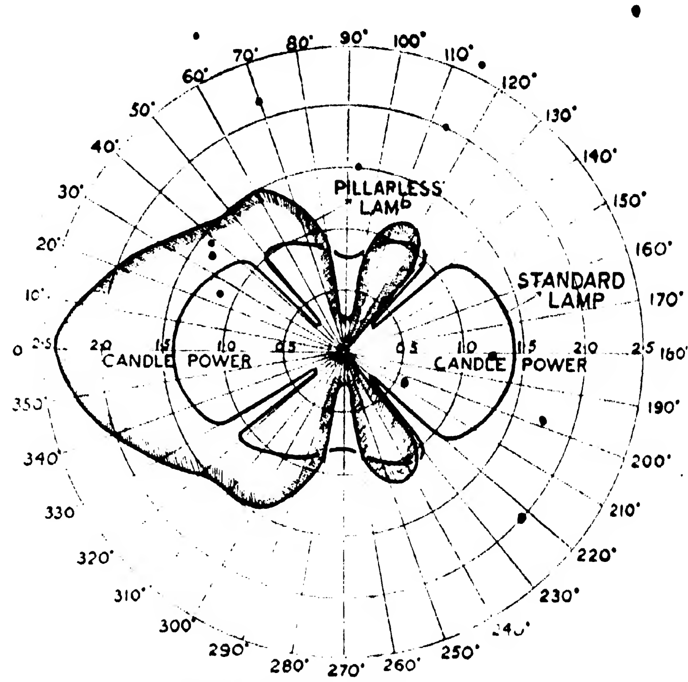
reflector, carried by a bridle, capable of swivelling in a larger bridle from two points at the side of the lamp top, this larger bridle also swivelling, as can be seen by reference to Fig. 2.

The large bridle is secured by heavy screwed pins, entering strengthening lugs riveted to the lamp top, the remaining portion of the lamp being built up of standard parts, interchangeable with the existing standard "Ceag" miners' lamp.

With the reflector down, an increase of light of 70 per cent. is obtained. There are no dark shadows caused by the lamp pillars, and a clear beam of light over an arc of 160 deg. is thrown forward.

The accompanying curves show the light given by the "Ceag" pillarless lamp, as compared with that given by a standard type of miners' electric safety lamp.

The reflector can, if necessary, be placed completely over the top of the wellglass of the lamp, or secured in any intermediate position by means of a thumb screw.



Polar Curve of Horizontal Light Distribution of "Ceag" Pillarless Lamp, compared against standard miners' lamp

It will be noticed that the curve showing the distribution of light for the standard lamp, shows four dark shadows caused by the pillars or protector rods, but gives otherwise an almost uniform all-round illumination. The elliptical shape of the light curve is due to the position of the filament, the bow of which lies along the axis 90 deg. to 270 deg.

The shaded area shows the light distribution in the same plane by the pillarless lamp. The dark areas due to the protector rods are removed, and a clear beam of light is thrown over an arc of 160 deg. The light falling on to the reflector is thrown forward, the candle-power in this direction being approximately 2.4 c.p., as against 1.4 c.p. with a standard lamp; this means that the illumination on the work is 70 per cent. greater, and the arc of light between shadows is increased from 85 deg. to 160 deg., thus giving a wide area of light of greater intensity.

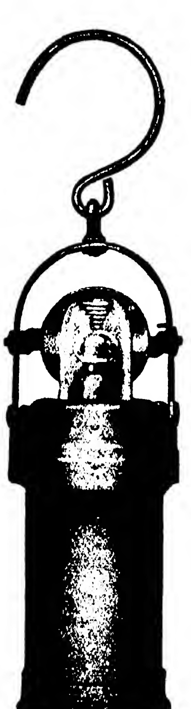


Fig. 1 Front Elevation

When the bridle is lowered, as in Fig. 2, the light given is represented by the standard lamp curve without any shadows. In this position the vertical distribution of light is very nearly ideal, and minute examinations of the roof, etc., can be made.

It will thus be seen that the pillarless lamp has many advantages over the standard type of miners' lamp.

The "Ceag" miners' standard lamp is illustrated in Fig. 3. This lamp possesses several patented features, not found in other miners' lamps, which features are also incorporated in the pillarless lamp, chief among them being a safety fuse, so arranged that in the event of the wellglass being broken, the circuit from the cell is automatically disconnected, and any part of the lamp which may thereby be exposed becomes electrically inert.

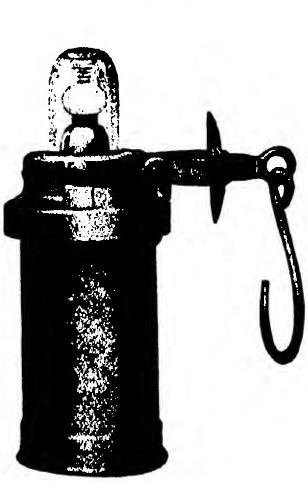


Fig. 2 All-Round Light

A specially designed conical spring is placed, through the medium of the bulb, in opposition to another spring, which serves to carry the bulb contact, and between these two springs the bulb floats.

These springs not only take up all vertical, but also all lateral shocks to which the bulb may be subjected.

The lamp is switched on or off by rotating

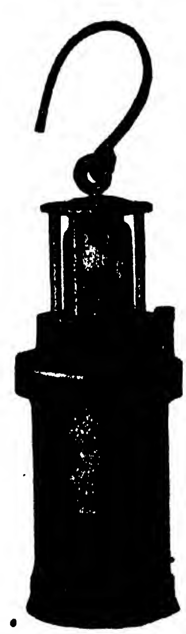


Fig. 3 Standard Lamp

the top relative to the bottom of the lamp.

The lamp can be supplied of a c.p. from 1 to 2, the higher c.p. being obtained over an 8-hour shift, the standard adopted being a lamp of 1.5 c.p. capable of burning for 12 hours.

The accumulator is of the "Jellac" type, containing no free acid, and there is, therefore, no corrosion of metal parts nor leaking of acid from the lamp.

The "Jellac" electrolyte (which name is the "Ceag" registered trade name for this solid electrolyte) is a chemical compound specially treated to remove deleterious substances which would cause local action and wasting of the electrodes.

The electrodes are circular in shape, thus ensuring maximum mechanical strength and complete freedom from buckling and short circuit, and are carried clear of the cell bottom by a special spacing insulator.

The lid is sealed by a patent sealing strip which can be cut through for examination of the electrode, which can then be taken completely out of the cell by raising the cell lid to which they are attached, and can be repalced without dismantling, after examination, if desired, and the cell sealed by affixing a celluloid sealing strip around the lid and case.

Engineering in Bacon Factories (ii)

(Continued from page 438)

BY W. A. TOOKEY, M.I.MECH.E.

Paper read before the Junior Institution of Engineers, London

THE type of weighing machine illustrated is such as is made by W. & T. Avery. It will be noticed that an overhead suspension bar is placed between the ordinary track rail, and by means of levers the weight is read off a steelyard, as in the ordinary platform weighing machines. At this point the weights are booked and recorded, it being the rule in some factories to pay the farmer so much per score dead weight. When, however, the pigs are bought on live weight, the machine is usually placed in a convenient position to the styes, and takes the form of a platform scale with wooden sides and hinged ends.

Refrigeration

In the majority of bacon factories ammonia machines are used for purposes of refrigeration, although others (such as at Redruth and Dunmow), fitted by Messrs. W. Douglas & Son Ltd., of Putney, are equipped with SO_2 machines. It is not intended to remark upon the relative merits of ammonia or sulphur dioxide, or of carbon dioxide, as refrigerant, it merely being requisite to state that whatever system be installed, the plant should be of ample capacity for the work to be done.

Successful bacon curing depends upon many things, but unless the proper temperature is maintained, failure and extensive loss results. Chilling must be carefully watched, and not be attempted in too short a time, otherwise the outside of the carcases will be chilled before the interior. A sufficiently long preliminary cooling period in the hanging room is essential.

In an ammonia system which was illustrated, the layout of direct expansion piping was such, that control was provided for a number of independent circuits for lard and offal rooms, pickle cooling, chilling, curing and baling. Attention was directed particularly to the air cooler, which is provided with an electric fan, and furnished with doors, so that air can be circulated round and round the chill room, the curing cellar, or both, as circumstances may require.

Power

A steam boiler is indispensable in a bacon factory for scalding, washing down, and in the various subsidiary processes, and economical production of steam is therefore an important problem. Oil burning furnaces have peculiar advantages, seeing that the dirt inseparable from coal and ashes is entirely dispensed with—a strong recommendation in any food factory—while the rate of steaming is always under control, and evaporation can then be made to accord closely with the varying demands. Besides this, oil is used for the singeing furnace, and the same fuel can be utilised to great advantage in the economical development of power by means of oil engines.

In a number of bacon factories, steam engines have been installed, but, as is well known, these are very uneconomical in the smaller powers, and the conditions of work in bacon factories are such that the waste heat in the exhaust steam cannot be wholly recovered—the greatest output of power, and consequent maximum volume of steam rejected, often occurring when least need exists for heated water. For this reason gas engines and producers have frequently been installed, because they operate at much less expense, but in the author's opinion there is a great future for the "cold-starting" oil engine in these factories.

Electricity is indispensable for lighting and for operating machines in various parts of the factory. Both individual and group driving is applicable—the latter in the fodder factory and sausage department, and the former for operating elevators, fans, pickle pumps, etc.

It is also most desirable to instal accumulators, so that current is always available to keep the circulating brine pumps and cold air fans in operation after working hours.

In moderate-size factories it is desirable to house the refrigerating machine, engine, dynamo, and battery

in a separate building, but much depends upon local circumstances, and full consideration has to be given to the peculiarities of each case.

Water Supply

At Elmswell the St. Edmundsbury Co-operative Bacon Factory obtains its supply of water from artesian wells sunk by Messrs. Le Grand, Sutcliffe & Gell Ltd. The first boring was put down several years ago, and was fitted with a small deep well pump capable of delivering 360 gallons per hour.

This supply was found to be insufficient owing to the great increase in the size of the factory, therefore in 1921 a new borehole was put down by Messrs. Le Grand, Sutcliff & Gell Ltd., the well being 6 in. in diameter and 178 feet deep, and an abundant supply of water was obtained from the chalk formation, the top of the chalk being reached at 118 ft. 6 in. below the surface; in other words, 118 ft. 6 in. of the glacial drift had to be first penetrated. These upper beds of glacial drift are, from a geological point of view, of quite recent formation, and consist of beds of clay, sandy clay, gravel, and sand.

A certain amount of water was met with in these beds at 30 feet and 47 feet from surface respectively, but as the water in these beds is frequently liable to contamination, it was shut out by 6 in. steel tubing, which lines the borehole, and which reaches from the surface and penetrates 6 feet into the chalk, terminating with a steel shoe which is driven tight into the chalk.

All the water, therefore, comes from the chalk, the borehole being unlined below the bottom of the 6 in. pipes. The actual level of the chalk water is 86 feet below surface, and this is pumped up by means of a deep well pump supplied by Messrs. Le Grand, Sutcliff & Gell Ltd., capable of raising 1,200 gallons per hour.

The chalk is the chief water-bearing bed of Suffolk, by reason of its thickness (over 800 feet in places), and by its large area of outcrop, the greater part of the water finding its way down and along the cracks and joint places, and other fissures generally so common in the chalk, and which can be seen in any chalk pit or cliff.

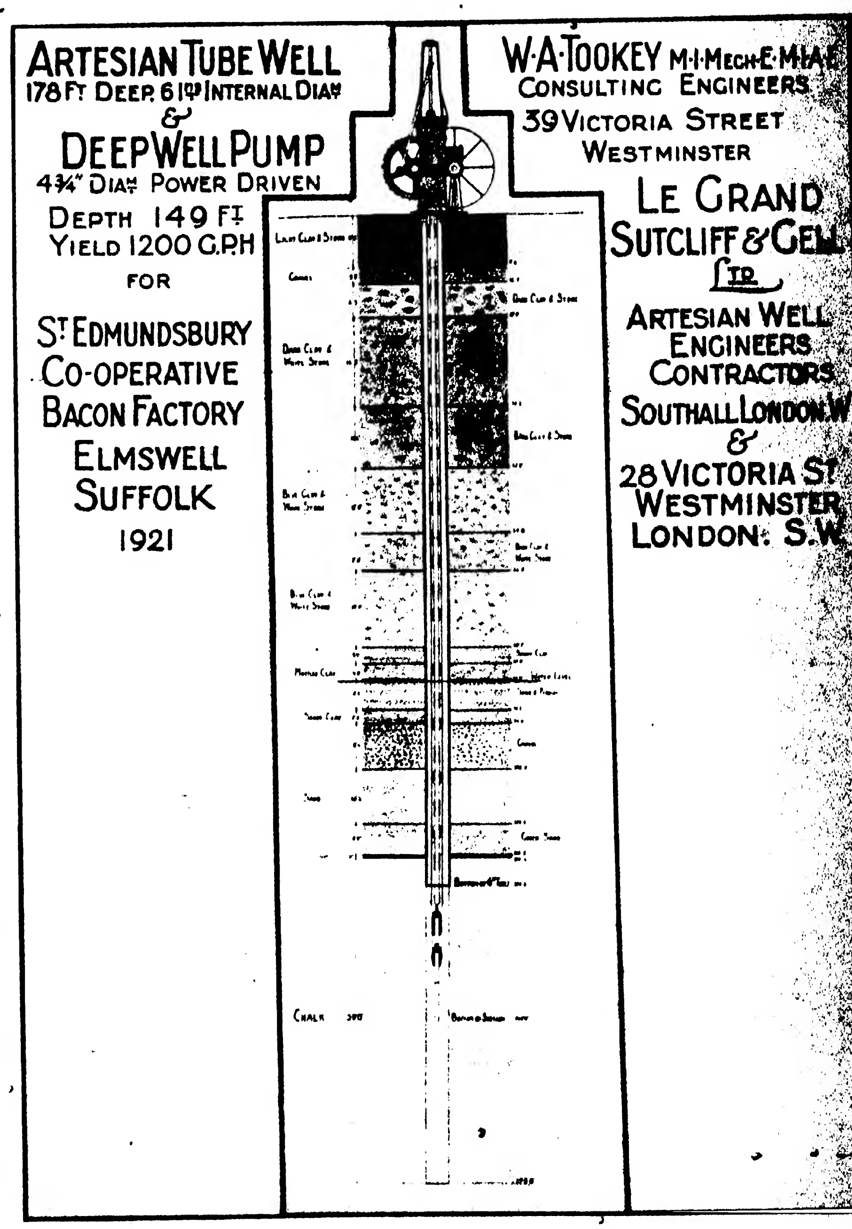
The source of the water, which supplies this well is from the great chalk outcrop which runs N.E. and S.W., running as far North as Hunstanton, and southward to below Hitchin.

A large reservoir, to hold 10,000 gallons, is now being erected so as to have ample storage capacity.

Sewage Disposal

This is a most important consideration, and, again, the peculiarities of each factory as to site, etc., must be considered. At Elmswell a septic tank and coke filter system has been installed by Messrs. Tuke & Bell Ltd.

All rain and clear washing water is drained off separately, and, passing a catch pit, eventually enters a land drain. The sewage proper is gravitated to a settling tank fitted with chain sludge pump and with compressed air effluent ejector chamber. The effluent is lifted to an elevated tank, from which it flows under a head to the automatically revolving sprinklers above coke beds 20 feet in diameter and 5 feet high. Subsequently the effluent flows to a land drain. As the factory has increased, so a further coke bed has been added.



Deep Well Pump

Le Grand Sutcliff & Gell Ltd.

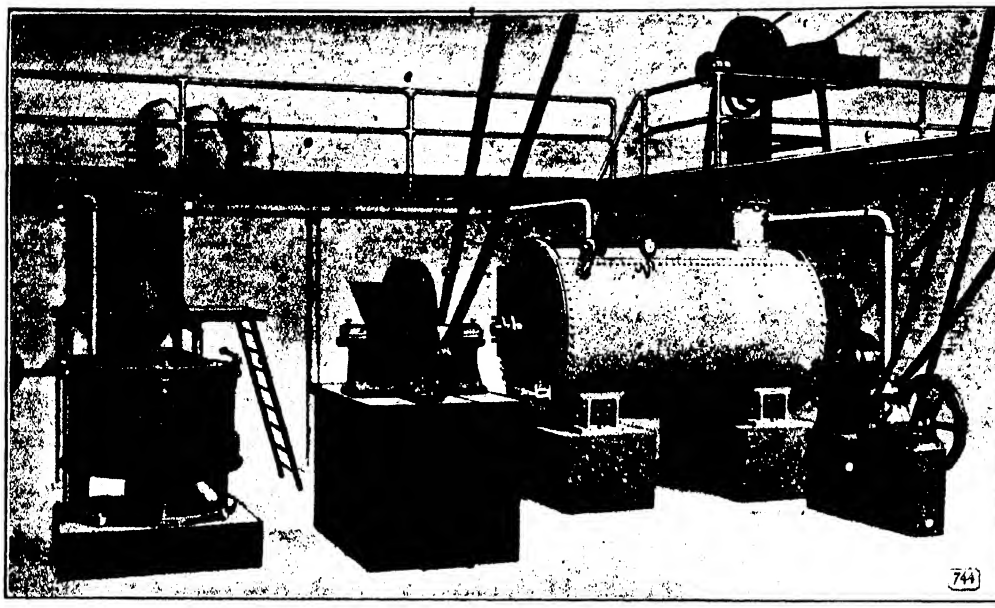


Fig. 1 — George Scott & Son (London) Ltd.

The peculiar difficulties arising from the dry summer of 1921, and the drying up of the land drains, caused some trouble, and special steps were necessary to deal with the difficulty, but, normally, the system has been successful in disposing of the sewage without difficulty.

Lard Machinery

The fat removed from the animal is rendered in steam-jacketed pans. The leaf fat is usually washed carefully, cut up into small squares, melted at low temperatures, and it is so easily rendered that no elaborate apparatus is called for. The rougher kinds of fat do not respond to this simple treatment, and besides being washed, cut and heated, require high temperatures to break down the enclosing tissues. Auto-boilers are used for this purpose, these taking the form of enclosed vessels, steam-jacketed, and frequently in connection with a vaccum pump, to obtain greater yields at lower temperatures. The product is afterwards refined in an open pan fitted with an agitating device, and arranged so that the jacket can be filled with steam or with cold water. The filling of the lard into bladders or other receptacles is from this vessel, or from specially designed lard fillers.

The systems adopted in various factories differ considerably, and personal preference, as well as the nature of local demand for lard, etc., influence the type of machinery installed in this department of the factory.

Gut and Offal

The cleaning of the guts is often done by outside contractors, whose staff are accommodated in this department. Strange as it may seem, women are the best workers at this job. No machinery is used in the process, so that no engineering interest invites a full description of it. It is sufficient to say that nothing is wasted, and all goes to the rendering pan or digester except the intestines, which, after thorough cleansing and sterilising, are used for sausage skins; the liver and lungs; and part of the heart, free from fat, which pass forward to the sausage factory.

Filter Bed — Tuke & Bell Ltd.

Digester

A complete plant for the recovery of fat and the production of fodder is shown in Fig. 1, as constructed by Messrs. G. Scott & Son (London) Ltd. In this will be seen, on the right, the cylindrical digester with stirrers on a horizontal shaft, and the belt-driven vacuum pump connected to the charging hopper—the latter being immediately below the chute receiving the small pieces of fat, etc., falling from the cutter shown on the gallery. The residue is ejected from the digester—cooled and subsequently "whizzed" in the centrifugal separator shown on the left. Finally, the dry residue is passed through the disintegrator depicted in the centre of the photograph.

Another type of similar apparatus is constructed by The Industrial Waste Eliminators Limited. Bone crushers, bone saws, etc., are necessary auxiliaries in a large factory to the digester plant; while, to avoid unutilised waste, catch pits are placed in the draining system, to collect fats, etc., which would otherwise be lost.

Condemned carcases are usually cut up and disposed of by the digester plant.

Blood Plant

The blood is cooled and converted into fodder for pigs, calves and

poultry, the apparatus necessary consisting of a blood agitating vessel, a lift pump, cooking vat, and blood press. The coagulated blood cake is cut up and dried, and is mixed with the product of the bone mill and digester. Some blood is used in the preparation of certain kinds of sausages, but a little goes a very long way, and the amount of blood to be disposed of is far more than can be used for these edibles. The fodder in which dried blood is ground up with residues from the digesters is excellent for pig food, so that it is highly suitable to feed pigs with the waste products of their predecessors.

Sausage Machinery

It is not infrequently the case that sausage making is omitted from the layout of a bacon factory. Much depends upon the locality, and cost of distribution. When thus equipped, the usual fat and meat cutters, mincers and filling machines are driven, and these are sufficiently well known to excuse lengthy description in this paper.

Pickle Pumps

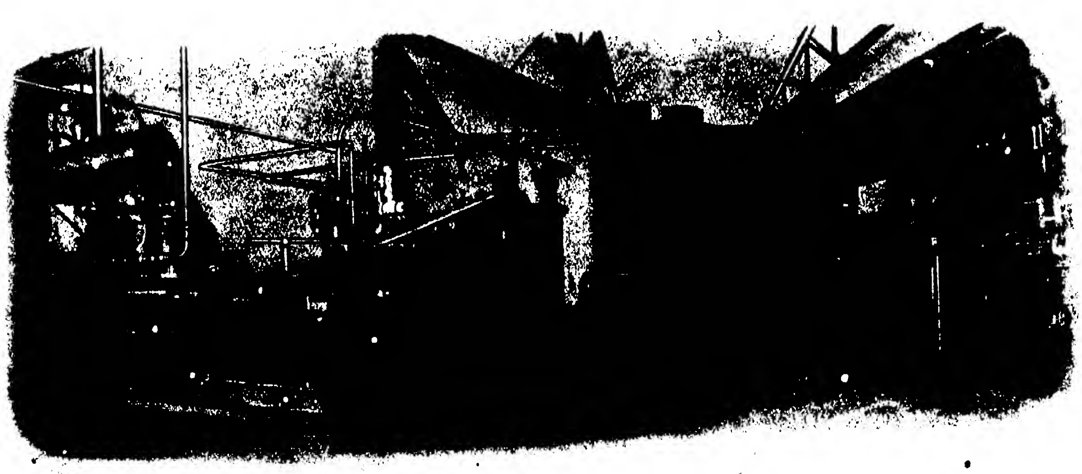
These are usually of the centrifugal type, for dealing with salt liquor and brine generally. For injecting salt into the animal through the arteries, a hand pump on a tub is usually fitted, and the injection made by means of a sort of hollow skewer, with perforations through which the pickle is forced into the carcase at a uniform pressure of about 60 lb. per square inch.

Weighing Machine

W. & T. Avery Ltd.

To be successful and profitable, a bacon factory must be well laid out in the first instance. Proper proportioning of departments is essential, and while quite a number have started from small beginnings, it is very necessary to have adequate machinery and engineering services to permit extension with economical working with full labour-aiding devices.

Certain firms have specialised in bacon factory equipment, and the author desires to express his obligations to Mr. J. Wendelbo Madsen, of Copenhagen, for a number of slides descriptive of Danish practice; and to Messrs. Wm. Douglas & Sons Ltd., of Putney, for loaning some of the illustrations. Messrs. Lightfoot Refrigeration Co. Ltd., The Industrial Waste Eliminators Ltd., E. Maundrell, Esq., of Calne, Messrs. Tuke & Bell Ltd., and Messrs. Le Grand, Sutcliff & Gell Ltd., have also assisted in preparing the diagrams and drawings exhibited.



Complete Refrigerating Installation

The Lightfoot Refrigeration Co. Ltd.

A Successful Pump

Manufactured by the Pulsometer Engineering Co. Ltd.

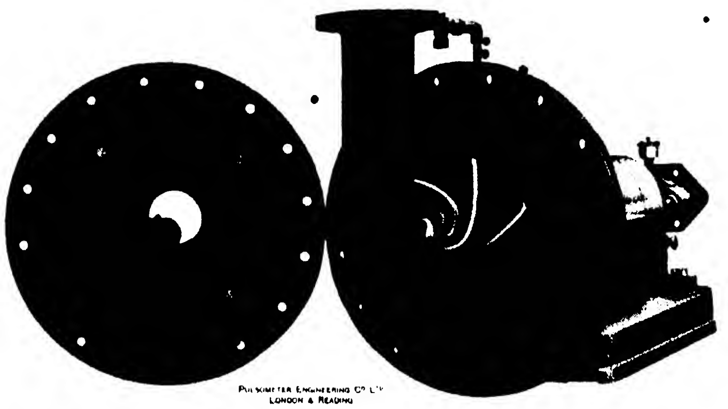


Fig. No. 2

IF engineering manufacturers derived any advantages from the trade slump, one was that of ascertaining with some degree of accuracy the extent to which their products might be called indispensable. The scarcity of money postponed the purchase of all but the most essential plant, and with so many competitors in the field, those manufacturers alone whose goods possessed the highest standards of utility were able to effect sales. It is interesting, therefore, to examine some of the products which showed up well in this enforced competition.

One of these was the Stereophagus pump. The volume of business transacted in this pump since its introduction has always been large, but its popularity has been a marked feature of the past two years.

As its name, "The Eater of Solids," implies, it was designed for pumping liquids containing a heavy proportion of solid matter, and its advent has solved some of the most difficult problems connected with the raising of sewage, from the mechanical as well as from the financial point of view. The removal of the necessity for screening, a troublesome process to say the least of it, is an achievement the importance of which cannot easily be overestimated.

The Stereophagus is essentially a centrifugal pump in appearance and in its method of operation, as will be seen from Fig. No. 1. The impeller, which is conical in form, carries scroll-shaped vanes, whilst in the casing there is fitted an adjustable knife blade, the cutting edge of which is fixed parallel to the face of the vanes, and in close contact with them from the point of the impeller outwards. To give an exact idea of what these items are, we reproduce in Fig. No. 2 a photo of the pump with the cover removed.

Any solid or fibrous matter which is unable to pass between the impeller and the casing is carried round to the knife blade, where it is subject to a slicing action between it and the impeller blades. This action is continued until the obstruction can pass the impeller, and is performed without shock, the cut being similar to that of a pair of scissors, viz., point by point along the knife blade.

The pump is thus self-clearing, and is capable of negotiating those solids found in sewage and bilge water, such as cotton waste, rags, rope, pieces of wood, tin cans, clinker, and debris generally. This is accomplished without the aid of strainers or other similar devices designed to prevent foreign matter from entering the inlet of the pump.

This absence of strainers, as well as of valves, and the freedom from accumulations round the spindles difficulties so common in the case of ordinary centrifugal and reciprocating pumps, reduces the amount of attention required to a minimum. The

(*Continued on page* 501.)

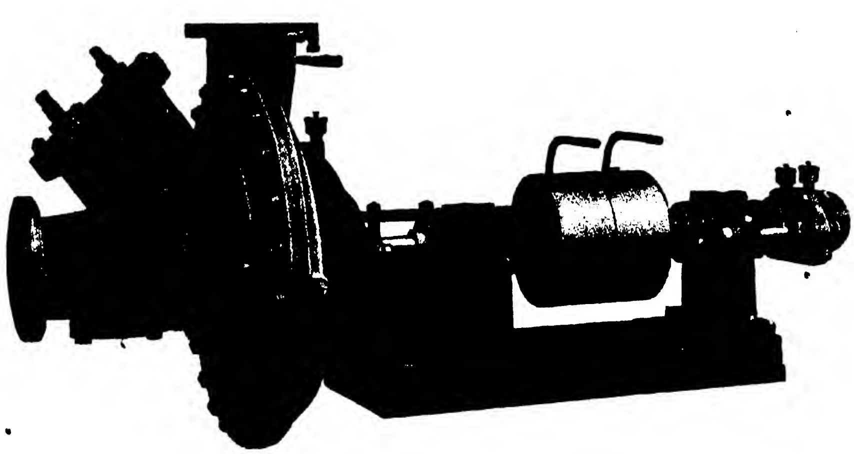


Fig. No. 1

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE :: :: :: :: DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS :: :: :: ::

The Scientific Control of Steam Boiler Plant

By DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S. Assoc. M.I.Min.E., Mem. A.M. Soc. M.E., A.I.Mech. E.

THE above is the title of an article appearing in the annual number of "The Paper-maker and British Paper Trade Journal" for 1921-22, and records the results of actual tests made under working conditions of forty typical steam boiler plants of the paper-making industry in Great Britain.

As is well-known, Mr. Brownlie has carried out similar systematic tests on boiler plant of different industries in Great Britain, some of which have been published, and we understand that the results obtained in other industries are to be published shortly.

The figures published in the article under review are highly instructive—the average nett working efficiency of the boiler plants of the paper-making industry is about 65 per cent., as recorded by Mr. Brownlie's figures, and he estimates that by carrying out the reorganisation of these plants on modern scientific lines, that it would be possible to operate them with an efficiency of, say, 75 to 77½ per cent., with, of course, a consequent saving in the coal bill.

Those interested in this important subject should obtain a copy of the publication referred to, as it is quite impossible to deal with the subject in the space at our disposal. We would say, however, that in addition to going into each item in detail, Mr. Brownlie publishes a table giving the actual results in the forty plants referred to. To give some rough idea of the amount of detail recorded, we would say that the table carries thirty-six columns, which is to say, that the details of these thirty-six different items are recorded for each of the forty plants.

We may perhaps, however, record one or two extracts from Mr. Brownlie's article as giving a further insight into the thoroughness of these tests. In describing the method used in carrying out the tests, Mr. Brownlie says: "A detailed test of the plant was first made for one working day, and a further test for one week was carried out as a check on the figures for the fuel used and the water evaporated, and to ascertain the weekly conditions, including all week-end losses due to stoppage of plant, etc. It is in many cases not the best policy to carry out a test for six or eight hours, as the figures obtained may be somewhat abnormal, and a week's test should be insisted upon. It will be clearly understood that the object of these tests was to find out the exact normal every-day working conditions of the plant, particularly as regards efficiency, and the cost in coal for the production of a unit of steam (evaporation of 1,000 gallons of water), so that a scheme of reorganisation could be devised for the more economical production of steam, that is to say, these figures represent the true performance of the plants as run from week to week. Many boiler tests are undertaken under what can only be called 'faked' conditions, that is to say, the plant is temporarily put into good condition, the brickwork repaired for the occasion, and the fireman and other attendants give a special amount of attention. In the same way very many detailed tests are given on plants where appliances are entirely new and working under the best possible conditions. This is one of the reasons why we are so used to reading reports on boiler tests where extraordinary results are being obtained, such as 80 per cent. nett working efficiency. On the above tests carried out by us, we have taken the greatest care to avoid these errors, and the boiler-house staff worked the plant as usual."

Another quotation as showing how steam plants are neglected on elementary points of keeping records, we will quote the following, which is a reference to the measurement of boiler-feed water:—"Out of the forty plants in only five cases was there any apparatus installed for determining regularly the amount of feed-water evaporated. It is absolutely hopeless to expect to get the most economical results on any steam-generating plant unless a proper system of recording the performance of the plant is adopted, and one of the most important points is the installation of a water meter to keep a constant check on the water evaporated. Probably not more than 5 per cent. of the boiler plants of Great Britain are fitted with water meters or other methods of determining the evaporation, and although the average for the paper-making industry on these forty tests is 12½ per cent., this is still a lamentable figure."

Finally, taking the following extracts from Mr. Brownlie's summary, we get a little insight into the importance of this subject:—"The grate length is generally too long, and not enough coal is being burnt per sq. ft of grate area per hour. The coal used is not analysed, and is used in ignorance of its heating value, and no continuous record is kept of the evaporation of the plant. For these reasons also, the steam out-put of the plant

is too low, and could be increased on an average by, say, 40-50 per cent. In many cases the feed-water is not properly treated, with resultant scale troubles. Full advantage is not taken of the economiser, the average saving being only about 12 per cent., because not sufficient tubes are installed, and the efficiency of the tubes in use is reduced because of scale and other troubles. The percentage of CO_2 is only 8 per cent., and Combustion Recorders are not in general use. Proper use is not made of superheaters, and a fair amount of steam, averaging 3¾ per cent. of the production, is used auxiliary to the production of steam.

"The general practice of using chimney-draught and steam-jets is, as a general rule, quite wrong, and mechanical draught is not utilised to anything like the full extent.

"Further, also with regard to the utilisation of steam in close association with the generation of steam, the boiler and steam pipe covering is apt to be defective and of inferior quality, and the average steam pressure is too low for the most efficient results.

"A modern plant run on scientific lines will give results of from, say, 75-82½ per cent. nett working efficiency, with ordinary steam coal or coke, depending upon the particular conditions of the plant.

"It must be remembered that the efficiency of any boiler plant depends largely upon the quality of the coal used. Thus, for purely refuse coal, the best efficiency obtainable may be only, say, 65 per cent., but with the best quality coal, the figure may be over 80 per cent. Speaking very generally, however, it will be correct to state that for all practical purposes an average nett working efficiency of 75 per cent. can be obtained for continuous performance. This figure is based on our 10-12 years' continuous experience on boiler plant work, which includes the reorganisation of scores of boiler plants under every condition, and is not a theoretical assumption."

Mr. Brownlie's final paragraph refers to the important question of keeping a complete weekly log, or, in other words, means a proper costing system and equipment for steam generation, and says:—"Many steam users have an idea that such an equipment is extremely expensive, and will not pay for the installation. This is not the case. Taking a typical boiler plant of six Lancashire boilers, burning 12,000 tons of coal per year, valued at, say, £24,000, the cost of a complete equipment of instruments, including water meter and accessories, automatic coal weigher, CO_2 recorder, bomb calorimeter, and general coal testing outfit, pyrometer installation, and recording draught and steam gauges, would cost less than £1,000. Taking the cost of a skilled attendant as £350 a year, interest on money at 6 per cent., and depreciation at 15 per cent., the total annual expenditure will be about £600 at the outside.

"The saving to be obtained by controlling the work of a boiler plant in this manner is on a most conservative estimate 10 per cent., that is, £2,400 per annum."

A Novel Lifting Magnet Equipment

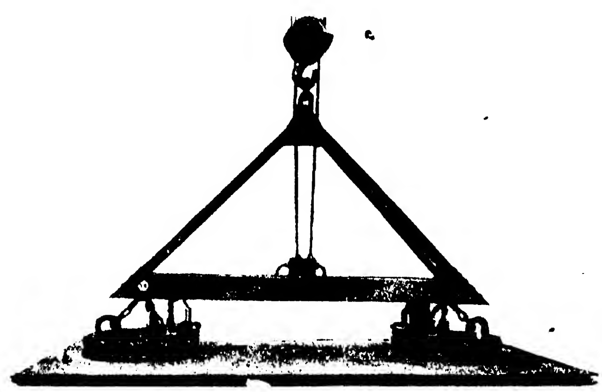
An interesting application of the use of electric lifting magnets is furnished by an order which has just been completed by the Witton Kramer Electric Tool & Hoist Co. Ltd., Birmingham, to the instructions of Messrs. Braithwaite & Co., of West Bromwich.

Our illustration shows one of four similar equipments which are being shipped to Bombay for use in unloading steel plates.

For a large pipe line which is being erected in Bombay, about 80,000 tons of steel plates will be used.

The plates are being shipped to India flat, and will be rolled into shape on site.

The duty of the magnet is to pick up four plates, 19 ft. × 7 ft. 4 in. × ⅜ in. thick, or five plates 15 ft. × 7 ft. 4 in. × ⅜ in. thick, either one at a time or in the complete bundle. They will then deliver the plates either into stock or into the bending machines one at a time.



Magnets in Use — *The General Electric Co. Ltd.*

In order to accomplish this, the magnets are arranged with special controllers, so that by varying the amount of current supplied to the magnet, it is possible to pick up one plate at a time. For example, starting with one plate, it is possible to go to another pile and pick up a second, move on to a third pile and pick up a third plate, and so on, and to drop them off one at a time alongside each of the four machines.

These equipments are only one of the many special types of lifting magnets produced at various times by the Witton Kramer Electric Tool & Hoist Co., who are specialists in the design of electro-magnets for every purpose for which this type of gear can be used.

Organisations for the Promotion of Industrial Welfare Work

By GLADYS M. BROUGHTON

THIS paper will deal with various organisations that minister to the needs of industrial employees outside working hours. I do not propose, however, to deal exhaustively with such agencies, but propose rather to ask the Conference to consider the different directions in which such work might be extended. If, therefore, I omit to mention any societies or any special branches of work, I trust it will be understood that the omission has only arisen because of the desire to spend more time in considering how such activities may be made to bring within the purview larger and larger numbers of industrial workers.

In Bombay, the Social Service League may well be taken as an example of a Society alive to the needs of the workers. It has established night schools in various mill areas, and has also opened reading rooms and libraries and travelling libraries. It also endeavours to provide medical aid by opening charitable dispensaries for men, women and children. Admission of destitute cases into hospitals is also secured. Complaints are sent to the municipality where insanitary conditions close to dwelling houses are found. An attempt is also made to provide recreation for employees by arranging for sports and open-air excursions. In addition, the Social Service League manages the Currimbhoy Ebrahim Workmen's Institute under the Agents to whom it belongs, as well as the Tata Institute.

These two institutes furnish useful examples of what is being done by enlightened employers. Members of these institutes have the benefit of reading rooms and libraries. A day school is also maintained for half-timers, and a night school for adults. A mill doctor is engaged to attend to the health of the employees, and in the case of the Tata Institute a woman doctor looks after the women. Employees are encouraged to save in the savings bank specially started for them. Loans can be obtained through the Co-operative Credit Societies. Stores on Co-operative lines have also been started, and have been largely patronised by the employees.

The Seva Sedan Society in Bombay may be described as the Sister Society of the Servants of India. It is entirely concerned with women and children; social, medical and educational work all come within its scope. The quarters of the poor are visited, and medical relief given, especially in confinement cases. Educational classes are held. Although industrial workers are helped when they are found in needy circumstances, yet this society is not primarily concerned with them, but with all cases of distress.

Calcutta and Madras both have their Social Service Leagues, but on the whole the problem of helping industrial workers, as such, has not yet been tackled very extensively in India. It is true that in comparison to the total population of India, the industrial population is very small. Now as the development of India's industries is vital if India is to take her place in the world, it is essential that the workers in these industries should have a standard of living which will secure efficiency not inferior to that of labour in other parts of the world.

The All-India League for Maternity and Child Welfare is yet another organisation which is doing useful welfare work, but, so far as I know, it has not allocated any funds specially for women industrial workers. Something is done in this direction by employers such as Tata Limited, the Sholapur Spinning and Weaving Mills the Kulti Iron Works, through maternity benefit schemes, but muc[h] more still remains to be done i[f] women industrial workers are t[o] secure the benefits recommended b[y] the Washington International Labou[r] Conference.

I propose to deal in turn with th[e] major needs of industrial workers, an[d] to suggest possible ways by whic[h] these needs could be more adequatel[y] supplied.

The first essential is good housin[g]. In a certain number of cases, thank[s] to employers, this has been secure[d], but, unfortunately, the growth [of] slums and unhealthy dwelling plac[es] seems to go hand in hand with t[he] growth of factories. While employe[rs] should be encouraged to build hom[es] for their employees, definite sugges-tions may be welcomed as to t[he] kinds of houses that should be pr[o]vided, if such provision is intend[ed] to secure a permanent labour for[ce] in place of one that is largely m[i]gratory. Whether it is desirable [to] create such a force in place of o[ne] that, by returning to agricultu[ral] operations, returns renewed and r[e]freshed for factory work, is a d[e]batable question, but where skill[ed] labour is required it is undoubted[ly] to the benefit of employers to reta[in] as far as possible the men they ha[ve] trained for their work. An Indi[an] worker does not expect very mu[ch] and is easily contented, but, li[ke] workers all the world over, he want[s a] place that he can regard as a hom[e]. The type of home considered de[sir]able varies in different parts of Ind[ia] but the attempt to provide such [a] home is well worth making. It w[ill] in most cases, necessitate the lay-[out] of more land, and this is often [an] almost insuperable difficulty. Th[ose] who wish to employ factory labo[ur]

however, should be willing to make some attempt to overcome this difficulty by buying land at some distance from the factory, and connecting it up by means of transit arrangements. Or employers might combine to plan out certain industrial centres in accordance with the requirements of their workers. Or they might help to start co-operative building societies by loaning the initial capital.

So long as municipalities are short of funds—and this seems to be true generally—the provision of suitable dwelling houses is bound to proceed slowly. There are, however, very hopeful signs in some provinces of a determined effort on their part to deal with the problem in so far as funds permit. Everyone has heard of the Bombay Development Scheme, and of the proposal to erect suitable houses for industrial workers in connection with it, but even the land reclamation scheme will scarcely provide enough space to meet the ever-increasing needs of that town. The Improvement Trust in Bombay has done much to better the conditions of life, but it, too, is severely hampered by lack of space.

Calcutta, too, has an Improvement Trust, but does not appear to have done much hitherto to tackle the problem on a large scale. There is less need there than in Bombay, as most of the large jute mills lie outside the city, and in a great many cases employers have provided houses for their own workers, but some of these settlements, too, are very overcrowded and insanitary. The overcrowding in Cawnpore is well known. There, too, in some cases, employers have endeavoured to meet the need by providing homes for their workers, and here I would like to say that some of the settlements in the town have succeeded in offering places that can be regarded as homes. The houses are built round a courtyard, and, in addition, each has its own private yard. Long avenues of trees give the place a pleasant appearance. Space has been provided for recreation, and in the evening children and men may be seen there thoroughly enjoying the opportunity of getting exercise in healthy, open surroundings.

The question then inevitably arises, what more can be done to provide adequate and suitable housing for employees? The first step, I think, is that the subject should be ventilated, and suggestions should be invited as to the kinds of houses that are likely to be appreciated. Large employers of labour and officials of the municipalities should then meet to draw up schemes enabling them to co-operate. Loans should be raised for building purposes, and schemes for co-operative housing be encouraged wherever possible. Factories should not be opened in congested districts. Transit facilities round large industrial centres should be made to serve the needs of workers wishing to enter factories. These suggestions are necessarily somewhat vague and general. The problem will differ in different localities, and will, in consequence, require to be handled differently. No stereotyped plan will be suitable everywhere. The need is, however, very general, and the desirability of tackling the problem on a large scale is self-evident. This, then, may well be the common starting-point of all schemes.

Food Supply

A suitable and inexpensive food supply is as important as good housing. But even in this respect the workers require help and education to make them realise that the amount of energy they can put into their work is dependent on the nutritive qualities of the food they eat. If an enquiry were made into the ordinary diet of a factory worker, it would be possible to trace the connection between the amount of energy he puts into his work and the kind of food he eats. There can be, I think, little doubt that such an enquiry would furnish useful information with regard to the kinds of food that should form part of the dietary of a worker. It might then be possible to arrange for a regular supply of the more important articles of such a dietary in industrial centres. In place of this, the employee is frequently faced with great difficulties when he has to make his purchases. When he first joins a factory he has little or no cash in hand, and has often to wait for more than a month before he can draw wages. He inevitably gets into debt with a local banyia, and finds himself forced month after month to buy from him owing to his inability to get rid of his initial debt. In this way he is prevented from getting full value for his money, nor has he the same freedom of bargaining, and of thus reducing the price. The success that has attended the opening of co-operative stores in mill areas should stimulate those responsible for the growth of the co-operative movement to enable the attempt to open such places in all large industrial areas.

The indebtedness already mentioned, and which seems to be the lot of many employees, is yet another reason why the growth of this co-operative movement should be encouraged. The co-operative credit societies that have been opened as a result of the effort of the Bombay Social Service League for mill employees have been successful. The experience that they have gained may well be made available generally. So far the co-operative movement has concerned itself mainly with agricultural workers, and the needs of industrial workers are only gradually beginning to be recognised. Attempts are being made in Bombay and Bengal, but the movement would spread more rapidly if propaganda work were undertaken, and if arrangements were made for starting co-operative credit societies and stores, and, at the same time, also providing facilities for saving. I have heard of men having to go all the way back to their own villages in order to take the money they have saved home, because no other way was open, or because they were suspicious of the Post Office. In this case the agricultural co-operative societies could do useful work if they linked up with industrial co-operative societies.

Besides good housing and suitable food supply, provision needs to be made for medical aid. This is provided to a certain extent by employers, and to a certain extent by the State and municipalities. The provision now available is, however, in many cases very inadequate to meet the needs of workers. Employers in some cases contribute to hospital, and so have the right to send their workers for treatment. In other cases they keep their own doctors. Here, too, however, they could do much by combining to secure a thoroughly efficient health service for their workers. Owing to the dislike of being attended to by men, women very often get no medical aid at all. In a few large towns there are hospitals for women only, supported by the Countess of Dufferin's Fund. They frequently, however, need advice for small ailments, as well as expert help at the time of confinement. The All-India League for Maternity and Child Welfare is doing something to supply this need, but the heavy infantile mortality in such places as Bombay and Cawnpore seems to call for much more thorough measures, and a very much more extensive system of relief than can be

secured by a body that is entirely dependent on voluntary subscriptions.

Next, if employees are to be rendered efficient, and to be encouraged to raise their standard of living, a great deal requires to be done to bring educational facilities within their reach. Education of factory employees, however, cannot be dealt with systematically until education is compulsory not only for children but also for half-timers, and until adults, too, can continue their education in evening schools. This is, however, yet a long way off, and in the meantime something is being done to fill this gap. The work done by the Servants of India Society in Bombay, and by such institutes as the Currimbhoy Workmen's Institute and the Tata Workmen's Institute, has already been mentioned. Employers in other parts of India are also helping in this direction. The Buckingham and Carnatic Mills have founded schools which are well known. These are, however, only a drop in the ocean. What is wanted is extensive propaganda work. Once the workers themselves realise their need for education, and ask for it, education will advance by leaps and bounds.

After thinking over the educational work done in this country, I have come to the conclusion that much of its utility is lost because it concentrates entirely on the education of children, instead of endeavouring to interest and to educate the parents. The result is that the children, after they leave school, have no incentive to keep up what they have learnt, and very soon forget it all. If, therefore, the State or municipal authorities endeavoured to provide educational facilities for adults, much of the labour and money that is spent on the education of children would not be thrown away.

Before closing, I would like to draw attention to the great advantages that ensue if arrangements are made for providing for the recreation of factory workers. Where possible, it should undoubtedly be the duty of municipalities to provide open spaces for games, and parks in which to rest. Cinema halls, too, if made subject to control, are also very useful for providing the necessary rest and change after long hours of work. Employers in different parts of India have, to some extent, attempted to provide for the amusements of their workers in their leisure hours, but much could be achieved if they would co-operate together, and with, the municipal authorities for this purpose.

I have only been able in the paper to deal in a somewhat cursory manner with the more obvious needs of industrial workers, and can hardly flatter myself that I have done more than break the ground; if, however, it helps to stimulate discussion, and to arouse interest in the subject, my object will have been achieved.

Fuel Economy in Colliery Boiler Plants

At a recent meeting of the Manchester Geological and Mining Society, a section of the Institution of Mining Engineers, an interesting lecture on this subject was given by Mr. Arthur Grounds. Mr. Grounds pointed out that Mr. David Brownlie had previously shown, based on many years' testing, that the average nett working efficiency of colliery steam boiler plants in Great Britain was only about 55½ per cent., and that this could be raised to 70 per cent. with any reasonable care and attention, even with the very mixed quality of fuels used in the average colliery firehole. This would mean an average saving of 21 per cent. in the fuel bill, that is 3,900,000 tons of coal per annum in British collieries on the present consumption of 18,000,000 tons per annum, 6¾ per cent. of the total coal raised. Mr. Brownlie was also of the opinion that collieries do not make the most efficient use of the refuse fuel available in the sense that too much good quality saleable coal is used, and if this defect was remedied at least another 15 per cent. in the coal bill could be saved, making a total saving of 36 per cent., or 6,600,000 tons per annum.

There is no question that in the colliery industry throughout the world, an enormous saving is to be obtained in the firehole in the two directions of more efficient burning of the existing mixed coals, and the utilisation of a much higher proportion of unsaleable fuel. Mr. Grounds is of the opinion that only about 15 per cent. of the coal burnt at collieries is definitely unsaleable, and very much more than this could be used. A very large proportion of colliery refuse contains a high percentage of ash, up to 50 per cent., through being mixed with shale and stone, but is dry and of suitable size. Material of this kind is best burnt on adapted chain grate and other types of travelling grate stokers under water-tube boilers, with suitable ash handling plant. The usual hard and acid pit water, which has created such a prejudice in collieries against the use of water-tube boilers and economisers, must of course be treated in a softening plant, but under these conditions very good results are obtained. Wet material, in the shape, for example, of "slurry" from the washing plant, having about 6,000 B.Th.U., with 20 per cent. water and 25 per cent. ash, is difficult, but it can be burnt with hand firing and very strong mechanical induced draught. Fine anthracite and other material low in volatile matter has always been particularly difficult, because of the trouble with ignition, but recent work in connection with the drastic alteration of the firebrick arches in the chain grate type of stoker, and the improvement in the design of the "Turbine" steam jet furnace, would indicate that this problem is beginning to approach solution.

Safety First in India

The illustrations in this article are reproduced from photographs kindly loaned by Mr. H. M. Surtees Tuckwell, M.I.Mech.E.

INVESTIGATIONS into the cause of accidents in industrial concerns which have been taking place in most civilised countries during recent years, have revealed the fact that machinery is not the principal cause of these accidents, but that, contrary to the general idea on this subject, the great majority of these accidents are caused by negligence and want of thought; or, to put the matter in a slightly different form, are due to lack of instruction and appreciation of the dangers in the modern factory.

These facts have been realised by those who have undertaken the promotion and development of the Safety First Movement. They have therefore inaugurated means for giving instruction so as to reduce the percentage of accidents, and the success of this movement is clearly demonstrated in the actual statistics which are now available in many industries.

It is very pleasing to note that the Indian industrialist has taken this matter up in a whole-hearted manner, and we propose in this short article to give the greater part of a contribution by Mr. H. M. Surtees Tuckwell, M.I.Mech.E., to the "*Safety First*" *Journal*, which gives a very interesting outline of the progress made by this movement at the Tata Iron & Steel Co.'s Works at Jamshedpur.

Incidentally we might mention that at a recent meeting of the British Industrial Safety First Association, it was decided to present three Indians at this firm's steel works with the Association's Award for risking their lives to succour others.

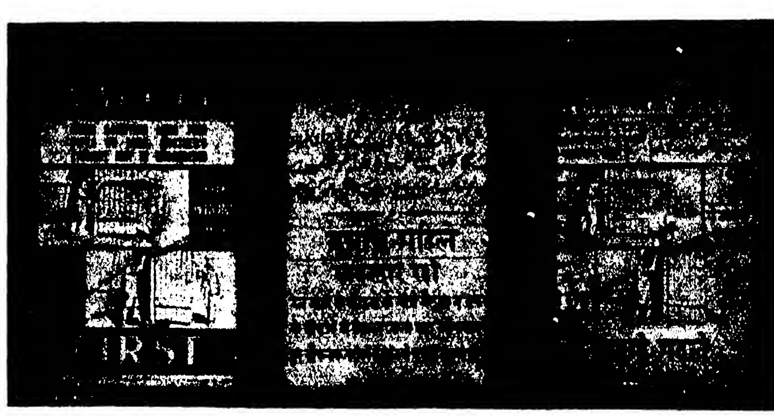
Mr. Tuckwell states that welfare work has always held a prominent position in the amenities provided by the Board, and when it is stated that the Chief Medical Officer and his assistants for the year ending December, 1916, had 154,857 patients through their hands, the importance of these responsibilities will be realised.

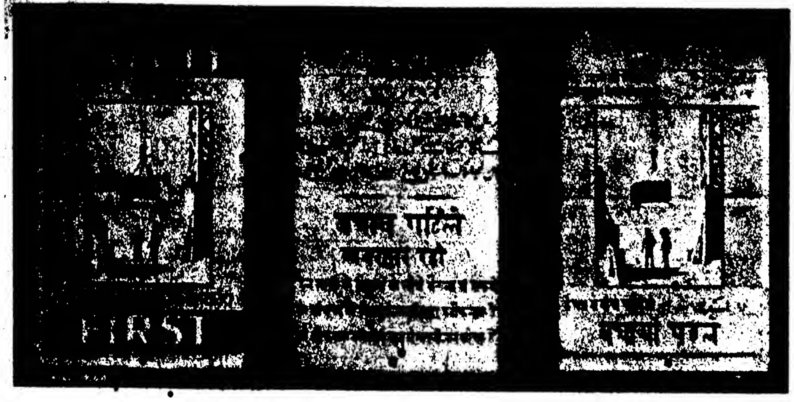
Land acquired for the works, housing, recreation grounds, sewage works, and various other purposes totals 15,000 acres, and roads, buildings, hospitals, schools and drainage have necessitated an expenditure of about 2½ millions sterling.

The Progress Committee

Prior to 1919, measures of safety propaganda were carried out by a committee of superintendents from the various departments, and was styled "The Progress Committee," whose duty it was to inspect plant, improve the equipment where necessary, and generally report progress. At the end of 1919 the title was changed to "Progress and Safety Committee," and in 1920, when the progress of the works was nearly completed, more safety work was introduced. Monthly meetings were held, and inspection of plant, investigation of complaints and reports was undertaken by the Committee. As the result of their activities, in the year 1920, 108 orders were carried out, including the guarding of machinery, safety devices, and other safety work. In the year 1921, 62 such orders were carried out, and up till May of last year 188 orders had been executed. These comprised fencing railway track, covering pits, drains, erection of danger warning and notice boards, guarding gears, pulleys, etc., covering electric switchboards, installing danger signal lights, and lagging exposed steam pipes.

In April, 1928, a suggestion box was instituted, and safety award buttons were given to the individuals who each month had made the best





suggestions. This proved very successful, and much interest was exhibited by the employees in the scheme.

Bulletin Boards

The B.I.S.F.A. bulletins and literature were widely distributed in the works, 12 bulletin boards were erected at prominent points round the plant, copies made of journals and sent to heads of departments. Two copies of bulletins are exhibited on each board—one in English and two translations in Hindee and Urdu. These bulletin boards are of very great interest to the workmen, who congregate round them and discuss the bulletins when exhibited. Special interest was shown in the B.I.S.F.A. Bulletin A, No. 27, illustrating the arteries of the body. The bulletins are changed weekly.

In May, 1921, 21 Departmental Safety Committees were formed of employees selected from each department. These work with the General Safety Committee, hold regular monthly meetings, and send minutes of their meetings to the General Safety Committee who consider at their monthly meeting the recommendations made. Also the General Safety Committee hold special meetings in connection with any fatal accidents which occur, examine witnesses, and obtain a report; also cases of alleged neglect likely to cause injuries are specially investigated.

First Aid classes are held; students, selected from various departments, are supplied with St. John Ambulance books; instruction is also given, and practical demonstration by the Chief Medical Officer. Forty-four students were attending these instruction classes this spring, and they are fully appreciated. Examinations are held at the end of the course, and certificates given.

In order to place before employees the constant need for care, blue-print charts are prepared showing the number of accidents in each department; each chart has twelve monthly spaces, and as figures are inserted month by month, the increase or decrease is shown on the chart. Careful records are kept of every detail of accidents, including particulars of cause and severity. Recent investigations show a large proportion of accidents are due to sheer carelessness. The reduction in 1920 as compared with 1919, was at the rate of 2.75 to 1.98 per cent. There was a slight increase in 1921, due to the great increase in the number of employees, and more dangerous work in the construction work, involving scaffolding, excavating, etc.

The results of the "Safety First" campaign have been very warmly appreciated, and we are informed by the Chief Officer that there is no doubt that the toll of accidents would be very much heavier but for the "Safety First" methods that have been adopted.

A SUCCESSFUL PUMP

(Continued from page 494)

adjustability of the knife blade provides for wear of the working parts, and ensures the maintenance of maximum efficiency.

The pump is manufactured by The Pulsometer Engineering Co. Ltd., of Reading, the well-known pump makers, and throughout the recent depression a remarkably steady demand for it was maintained. It is now to be found in most districts where the sewage is specially thick or full of hard substances, and the number of cases in which installations have been running for many years on constant hard work, without replacement of parts and without trouble of any kind, is very large.

The Stereophagus is the invention of the Hon. R. C. Parsons, and can be fitted up for any type of drive.

The spirit level which is mounted on practically every kind of surveying instrument is one of the simplest and most familiar of appliances, but it is only lately that thanks to the ingenuity of a British firm one of its essential faults has been removed. The ordinary bubble is not always accurate, because its length alters according to whether it is hot or cold. In the new spirit level referred to, the tube containing the liquid is so shaped that as the temperature rises, only the breadth of the bubble is affected, and its length remains quite unaltered.

Fitting the Young Engineer for Public Service

Some interesting American views on the important subject of training for the Engineering profession

OWING to the attention now being paid to the questions of the training of young engineers, and their fitness for future social service, the views of two prominent American engineers are of interest.

Mr. Frederick Bass, who is head of the department of civil engineering at the University of Minnesota, says that a number of arguments have been presented in favour of the proposition of a six-year curriculum for engineers, the first three years of which would be devoted to a liberal training in fundamentals. One of them is that it would eventually result in securing for the engineering profession its proper place in public esteem. This may be a desirable result of such a curriculum, but it cannot be considered as an adequate objective.

A calling meriting the distinction which attaches to the term "profession" must require of its members an obligation to render service individually and collectively beyond the remuneration or immediate recognition which they receive for their labour. The soldier, the priest, the physician, the lawyer, all are accorded a professional status, because their lives are primarily devoted to the solution of the great human problems of preservation of social order, spiritual welfare, prevention and cure of disease, and the administration of justice. It is true that all members of these professions do not take this view of their occupation, but that does not invalidate the definition of a profession. All engineering societies announce service to mankind as the purpose of engineering. Altruism is the essential motive of a profession.

The engineer may look forward to the day when his calling will be accorded a professional standing, but only when the preponderance of engineering thought and conviction is based upon the conception of engineering activity as an agency for devising economic and just solutions of the greater problems of production and distribution. Engineering practice has grown up from the constructive arts as applied to materials; it later adopted the methods of science and developed enormously, particularly in the last half-century, but has been generally considered as limited to mechanical or chemical achievements.

An increasing proportion of men receiving a formal institutional training has entered its ranks, men who sense the limitations of the mechanical concept, and who realise after having mastered the technique of their chosen province, that they have been out of touch with the greater human forces underlying their occupation. Engineering is a part of business, and most business to-day is conducted with an overwhelming regard for immediate profits. While profit is necessary for the continuance of business, the professional man, as a participant, must regard profit as subordinate to the real needs to which the business ministers.

A business conducted upon this principle will possess a stability which enables it successfully to meet irregular demands for its product, as well as internal disturbances. The professional man, in business or not, must regard himself as a trustee of wealth. This viewpoint is not lacking among the ranks of many of the greater financiers and business men of to-day, nor among the leaders of public life. These men are building for the future in a large way.

Range of Vision

Since engineers are, because of the need of their scientific training, entering the management field, which includes the technical field, they have before them the prospect of taking an important, if not a dominating influence, in the conduct of commerce, industry, and public affairs, provided that is accepted as the objective of their training. If the engineering fraternity becomes sufficiently impressed with the value of the training now received in engineering schools in accurate observation, correct analysis and interpretation, and the design or formulation of constructive programme, can visualise its beneficial application to business, public or private, can add to it the professional sense of trusteeship, and can bring pressure to bear upon engineering education to accept this greater range of vision, engineering need not remain a subordinate occupation; it will attract the highest type of man, because his opportunities will not be subject to the limitations of the present.

Length of Course

If it be the objective of engineering to provide merely for the routine investigation, designing, construction and operation of structures and equipment used for production or distribution, the usual four-year college course is probably too long, but if it be the mission of engineering to carry its analytical and synthetic methods into the business of which it is a part, then the four-years' course is insufficient either to attract or to train the type of man who must master not only material but great social and economic problems. Not only a longer course of study is needed, but a different type of study, one motivated by an ideal and provided with a practical programme.

Mathematics and physics are generally regarded as the sole fundamental studies in an engineering course, because they supply the knowledge of natural law and the means of correctly interpreting it. But a comprehensive knowledge of history, political science and economics is none the less essentially fundamental in the training of the engineer of the future. Not only should these subjects be included in

a professional engineering curriculum, but they should be connected definitely with the problems of industry. Frequently the engineering student has an opportunity to get a smattering of these subjects, or of their subdivisions, but they are often regarded by him as incidental, because taught as having only incidentally a relation to engineering. The same observation may be made of means of personal expression.

The engineer is usually taught to express his thought almost exclusively in the form of mathematics, graphical drawings, and structural or machine design. Excellent as are these concise means, he almost universally is deficient in the facile use of written and spoken language. His poverty in this respect is the subject of common observation. He is confined too exclusively to his adopted method, and thereby loses the power to communicate with groups of men whose thought runs perhaps in parallel, but different channels. The engineer's training tends to narrow channels which are frequently worn so deep that he, working industriously at the bottom, never looks over the top, and often he cannot if he will. The usual engineering course needs more language, both oral and written, English and foreign.

The engineering student needs to know where his work in its simpler phases impinges upon that of individuals and groups in other occupations and professions; as a practising engineer later, he will then appreciate where it overlaps and merges in more complex situations, and the path which his non-engineering associates have travelled in arriving at the point of juncture with him, as well as the ground which they occupy at the time. Every professional engineer should better understand non-engineering people and their various modes of thought, expression and action, the reactions among groups, and especially their significance at this unprecedented period of world history.

Having set an ultimate objective, and marked out some of the means by which it may be reached, it becomes possible to discuss the features of an education which will prepare engineers for their destinies. The plan of a six-years' course, the first three years given to a course in the college of liberal arts, followed by three years in engineering, presumes that broad foundation is laid in the first period. The foundation suitable for any superstructure generally requires some preliminary excavation, which, in the situation before us, means an opening of the student's mind by exciting his interest and motivating his study.

The means by which this can be done must be by a co-ordinated curriculum, administered by men who know its meaning and purpose. Many of the instructors in the junior years of colleges of liberal arts to-day are themselves highly-trained specialists who have won their places by research in restricted fields. Moreover, such colleges are, as a rule, divided into departments, one might almost say compartments, without sufficient means of inter-communication.

If the earlier years of a student's course can be so planned that he can pursue courses in English, economics, political science and language, in parallel with engineering, and have their inter-relations made evident to him, there can be no doubt but that an ideal training would result, but this correlation should be assured before such a plan as Professor Burr purposes is adopted. As expressed by Dean Cooley, of the University of Michigan, a "ribbon" system, instead of a "block" system, should be used. The ribbons should be woven into a substantial fabric.

Grading

The point is made that all of the students desiring to pursue engineering cannot afford to do so if the course is made as long as five or six years. This is no argument at all; there are to-day many boys desiring to study engineering who cannot afford to take the necessary four years from productive effort; should we therefore reduce the course to three years or one? There is nothing inviolable or sacred about the figure four; if the demands for the best service which the engineering profession can give require five or seven years, then it becomes the duty of the engineering schools to furnish that training.

Probably the lengthening of the curriculum would result in fewer students. No doubt it would at first have a very marked effect of this character, and possibly a permanent one. This would leave the demand for draughtsmen and field, shop or office assistants unsatisfied. It is in all probability true that a considerable number of young men enter and graduate from four-year engineering courses who would have done better both for themselves and the colleges in which they studied, to have terminated their course at the end of two years.

These are men who have the type of mind that develops almost wholly through practical experience, men who may be satisfied with, or who may be limited to, action in the more restricted fields of engineering. Concurrently with the introduction of longer courses in engineering, the present four-year courses should be retained, or, better, shortened to three or two years, and, as experience dictates, revised in character. Graduates from such courses should be given a certificate of graduation, possibly conferring a title, such as "Graduate in Engineering from Junior College."

Mr. Bass is of the opinion that these shorter courses should be offered in universities only in localities where there are no other schools to give them, such as Wentworth Institute, in Boston, or the Dunwoody Institute, in Minneapolis. State universities must, on account of the expediencies of the situation, often develop with less freedom than the endowed universities, and consequently be required to administer courses not really of collegiate grade.

In any course of engineering, it is his opinion that a close identification of the student's classroom work with the practice of engineering, and with industry, should be maintained. It required enormous persistence, patience and labour to establish the co-operative courses at Cincinnati, but the experiment has been successful, and in modified forms the plan is being followed elsewhere.

It cannot be maintained as a simple proposition, that all engineering courses should be standardised at six instead of four years. But it can be truly said that the engineering profession has before it a formidable task in projecting its ideals of service and its scientific methods into public affairs and industry, and that in this greater task a more broadly-trained engineer will be required than in the past. The combined efforts of teachers of engineering, and of the most far-sighted men of practice in engineering, will be necessary to study the present situation in the light of future demands, in order that a well-balanced programme may be formulated for the training of members of the future profession of engineering. Such a study should be amply financed over a period of several years.

The view of Mr. Hale Sutherland, assistant professor of structural engineering at the Massachusetts Institute of Technology, is that whether any particular engineer is a professional man is often a very debatable question. That engineering is a profession, can hardly be questioned, although its qualified practitioners, fully entitled to professional status, are not yet sharply defined as a legal group by any general system of licensing, as is the case with our doctors and lawyers. The clear-cut definition of the Century Dictionary may be used to establish this contention: A profession is a "vocation in which a professed knowledge of some department of science or learning is used by its practical application to the affairs of others, either in advising, guiding or teaching them, or in serving their interests or welfare in the practice of an art founded on it. The word implies an application of such a knowledge to uses for others as a vocation as distinguished from its pursuit for one's own purpose."

In arguing the case, the tendency often has been to emphasise the technical qualifications of the engineer, the extent and depth of his specialised knowledge, and his expert judgment But an essential element of professional work is the application of this expert knowledge to the use of others. The professional man deals always with clients to whom he owes a peculiar loyalty, yet he may not favour one client at the expense of another, and in the largest sense his loyalty is to society, the sum of all possible clients. The humanitarian ideals have always bulked large in the thought of the learned professions, and the masses have always turned to these groups for leadership, even outside their limited fields of professional knowledge.

This standing apart of the professional man as bound by purpose to a larger end than his own individual advancement, is of immense significance. The struggles of opposing interests and ideas in our civilisation to-day are so tremendous, the results so uncertain, and of necessity bound to be so far-reaching, that the average man stands uncertain and aghast.

He is sure of but one thing, and that is that there must be less of conflict, more of co-operation, and this principle he applies to the solution of all difficulties, large and small. In this judgment he is supported by the sociologists, who tell us that the advance of civilisation is measured by the advance of the idea of co-operation. Now the spirit of co-operation is pre-eminently the spirit of the professional man, and one writer has gone so far as to say that society progresses in the measure that additional groups of workers take as their own the standard and purposes of the profession.

So in the larger view of things, the demand of the engineer to be counted as standing with the minister, the doctor, and the lawyer, is not a mere seeking of selfish preferment, but is a declaration of his recognition of his function in the work of the evolving race, of his duty to place his specialised knowledge at the disposal of society for the advancement of all. Anyone who has read of late the writings of engineers supporting their claim, cannot have failed to note the large place taken by the thought of community loyalty.

The justice of Professor Burr's plea for the full professional training of the engineer is therefore easy to establish. Every engineer should grasp the full significance of the demand he makes when he seeks recognition as a professional man. No engineer can understand the significance of this claim and merit the higher rating unless he has gained a sympathetic knowledge of mankind's advance up from the savagery of the prehistoric past into the complex and disordered present. Only such knowledge can face intelligently and without prejudice the pagan logic of the reactionary and the maudlin sentimentality of the radical whose clamour confuses our ears these days. Wisdom and good will are needed to solve the problems that threaten civilisation, and the professional man is bound by his loyalty to a leading part in their solution.

History

The sympathetic knowledge that will command this loyal purpose must of necessity include certain definite subjects. The story of the life of man on this globe from his earliest beginnings to the present, the story of the various community groups he has formed and now maintains, their varying fortunes, the organisation and direction of these groups, the ways in which they have made and now make their living, the nature of their environment, the laws of the natural world in which man lives, and the efforts he has made to arrive at an understanding of life by rational inquiry and by emotional evaluation.

History, the humanistic sciences (sociology, economics, government), natural science and mathematics, philosophy, literature: here are five fields of learning in which a man must have real understanding if he is to comprehend the significance of the vast evolutionary procession in which we move and work intelligently for progress. And, of course, to perform his special task in society, the professional man must have expert knowledge and ability in his chosen speciality. Can the engineering profession do less than demand that in the future its members receive a training of this scope?

One of the most vital and interesting of recent contributions to educational discussion is Mr. H. G. Wells' proposition that the backbone of education is history. He is asserting the same thesis that is here maintained, that the schools should open to us the broad horizons of the evolving world race, and set our own interests and purposes to racial ends. He is not greatly interested in dynasties and dates, but he is very much concerned with getting a clear picture of what man is like, his ways, thought and doings, past and present, that explain man to-day and the world situation by which he is faced. He makes this background of the past and the vast conflict of the present very live and real in his "Outline of History." One comes from a reading of that book with a vivid idea of what the word "history" really means and with a vast aversion to the scholastic deadness that so often masquerades by that name.

As history requires to be related to the living processes of the present, so all subjects are under the same necessity if they are to have living force. That which is studied for itself, for its own interest or beauty, is a scholastic, a dead thing. When this principle is adhered to, a course in Latin has living value. What are our memories of our schoolboy Latin? When this principle is disregarded, our courses in history, social science, and literature become dead and vapid scholasticisms. So it is not enough to outline a curriculum. Nor will it be enough to specify "All courses shall be so arranged and taught that the significance of the subject in the life story of humanity shall be plain." The end can be attained only by ensuring that our teachers be men of vision first, and scholars second.

TRANSPORT

Conducted by " M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH THE MANAGEMENT AND CONTROL OF RAILWAYS

The Grouping of British Railways

The merging of the railways of Great Britain into four large systems, under the terms of the Railways Act, 1921, presents one of the biggest railway reorganisation schemes, short of nationalisation, that has ever been attempted. This article discusses recent developments, and indicates future possibilities. The lessons are not without interest for India and other countries.

WITH the year 1923, a new era dawned for British Railways. Ere the year passes into the vista of things forgotten, the hitherto many-competing and privately-owned railways of Great Britain will, under the terms of the Railways Act, 1921, be merged into four great systems. The transition from the stage of wholesale competition and individual development to one of greater corporate activity is undoubtedly one of the biggest railway reorganisation schemes, short of nationalisation, that has ever been carried out, but one that will be eclipsed in greatness of conception by the grouping scheme now under consideration in the United States, where, however, about eighteen groups are forecasted.

A scheme of this magnitude is, obviously, one that cannot be carried forward to fruition without a good deal of discussion, oftentimes acrimonious, but that, even then, it can be effected by negotiation between the railway companies themselves, is a tribute to the foresight of those responsible for their management and the sanity of the directors and shareholders. Towards the end of last year, the titles of the new systems were published. These are the London, Midland and Scottish Railway Company; the London and North Eastern Railway Company; the Great Western Railway Company, and the Southern Railway Company. The only one retaining its original title is the Great Western, which, being the only, or at least the only important constituent, company in its group, had its name officially laid down in the Schedule to the Railways Act. The other names—and, indeed, the Great Western also—indicate the territory served by the grouped companies. The London, Midland and Scottish Railway Company comprises the old London and North Western, Midland, Lancashire and Yorkshire, North Staffordshire, Furness, Caledonian, Glasgow and South Western, and other companies, and, as its name implies, serves the Midlands and the North, *via* the West Coast. The London and North Eastern Company includes the "three Greats"—the Great Central, Great Northern, and Great Eastern,—the North Eastern, the North British, and other companies, and while definitely competing with the London, Midland and Scottish Company for traffic in the Midlands, primarily serves the Eastern Counties and Scotland *via* the East Coast. The Great Western arrogates to itself almost a complete monopoly of transport by railway in the West of England, and throughout Wales, while the Southern Railway, except where it competes with the Great Western in the south-west of England, and with the London, Midland and Scottish, serves exclusively that portion of England situated south of the River Thames.

A Great Change

So much for the new companies and their names, though, in passing, it may be recorded that there is a strong body of responsible opinion in England which considers that the names might well have been shortened to Eastern, Northern, Western, and Southern respectively. Incidentally, the adoption of these simple one-name titles, while thoroughly indicative of the scope of the various companies, would have realised substantial economies, if only in connection with the painting of new stock, the printing of posters, the inclusion of the initial letters on uniforms, and the like. But, with the usual stubbornness of the Briton, each of the more important constituent companies stuck out for some portion of its original title to be brought into the new name! And the clumsy titles adopted by two of the companies is the result.

Those who are not conversant with what has been done, and the reason for so drastic a change in the national policy towards railways, may well wonder what has caused such an upheaval. It can be explained in comparatively few words. There can be no possible shadow of doubt that towards the end of the war, during which period the railways were functioning as one unit in the interests of the State, the Government had decided on nationalisation. In fact, Mr. Churchill, a Cabinet Minister, stated as much in the course of his election campaign at Dundee during 1918. Accordingly, a move was made in the desired direction by the establishment of a Ministry of Transport, the Minister being Sir Eric Geddes who had performed such magnificent transport feats during the war. That the new Ministry was intended eventually to take over the railways of the country "lock, stock and barrel," is at this time, indisputable, but as time went on, both traders and the public began to voice their grievances against Government control of railways—the control continued for some two years after the war,—and the responsible authorities began to reconsider their policy. Then came the intention to form the railways of the country into large groups, and after the various schemes had been published, and their potentialities sifted

it was left to Sir Eric Geddes, in the monumental Railways Bill, to bring in a definite scheme for the purpose of consolidating railway properties in order to effect economies of no mean order. The Railways Bill had a somewhat stormy passage through Parliament, but it emerged with its main object clearly defined—the consolidation of nearly all the railways of Great Britain into four large groups, and the arrangement of a more definite control by the State than has hitherto existed in any country where the railways were privately owned.

Points in the Grouping System

Among other things, the Railways Act of 1921 established a Rates Tribunal, the functions of which are now well known in India by reason of the Acworth Committee's recommendation that such a body should be constituted there, while it also laid down that the railways were entitled to earn a "standard net revenue" equivalent to a certain percentage on the capital. The Rates Tribunal were to fix rates that would secure this return to the companies, and wherever the companies, by efficient administration and working, managed to obtain surplus profits, 80 per cent. was to go in reductions in rates and fares, and the remaining 20 per cent. might accrue to the companies' funds. In this connection, it might be worth while to notice that, whereas in the United States, the companies were "guaranteed" a return of a certain percentage on somewhat similar lines, the companies have, in fact, never earned it, and while, according to the accepted method they should, therefore, raise rates and fares to improve their position, the general demand is for cheaper rates and fares.

Then again, the Railways Bill, 1921, rules out competition except at the relatively few points where the big systems touch. This is, of course, an entire reversal of previous railway policy. It had hitherto been an accepted form of British parliamentary procedure that, as "competition was the life-blood of commerce and industry," no action should be taken that would in any way take away the advantages of such competition. For this reason, as much as any other, the proposed amalgamations brought before Parliament in recent years had been turned down, and, where not absolutely rejected, hemmed in by so many provisions as to render the schemes unattractive to those concerned. Whether, under the new conditions, the public is to benefit, is a matter for the future to decide. It would certainly seem that, speaking generally, huge monopolies have been formed, and while their operations are subject to many controls, one being the right of any individual to appeal to the Tribunal where he considers he is being oppressively treated, this of itself would not appear a sufficient safeguard against the naturally monopolistic tendencies of large concerns.

While stating that, in my judgment, the public will derive no material gain from the new railway policy, I must make the qualification that much depends upon the people responsible for the administration of the new companies. It is certain that in some respects there will be improved facilities for travel, and possibly in the long run slightly cheaper facilities, but whether this will make up for the absence of the competitive spur, time alone will show. The new railway plan is, indeed, a bold measure, and it will be interesting to watch the gradual unfolding of the plans of the management.

Advantages of Unified Working

It is, of course, well known that for years past British railways had been moving in the direction of a consolidation of their resources, and had it not been for the war, there can be little doubt that the process of merging, at least by the establishment of working agreements, would have been carried much farther. Each of the large groups had arrived at certain mutual arrangements with regard to traffic conveyance, and in so far as this had been done, no particular advantage will accrue from the complete amalgamations now inaugurated. Where advantage will accrue, however, is in the fact that the whole basis of the transportation arrangements will be widened, and that a more economical use of both locomotives, rolling stock and traffic facilities will be rendered possible. Moreover, under the intensive form of organisation that will inevitably be adopted, the railway companies will more and more tend to standardise their supervisory arrangements, and this of itself should lead to considerable savings. Where, for example, each company serving any large town has hitherto had its own goods agent and stationmaster, it is certain that in future there will at the most be only one goods agent and stationmaster for the grouped company, while it is probable that in the evolution to a more scientific stage of organisation, the ultimate result will be the appointment of town or district managers directly responsible to their divisional heads. But, at most, this phase of the subject is one of internal policy, and it may be well, therefore, briefly to outline the prospective advantages that are likely to accrue to the traders and the general public.

Firstly, then, it may be pointed out that whereas through rates were under the old *régime* based upon the various charging powers of the individual companies, the higher rate thus applying from the junctions between adjacent systems, this will be changed entirely under the new system. In such a way, the trader whose traffic travelled over several lines will be placed in the same position as the merchant whose service was more or less confined to a single system. In other words, the charges will be based on a system of continuous mileage, so much per mile for the first portion of the distance, so much for the next portion, and so forth. This undoubtedly clears away one inequality that was productive of considerable controversy, and, as it places all traders on the same general level, it is indisputably an improvement on the old method.

In the matter of rates, also, an entirely new classification arranged on a very wide scale has been arranged by the Rates Tribunal, and that body is now engaged in deciding precisely what traffic shall fall in the various classes. Additionally, a greater measure of elasticity has been accorded in the matter of exceptional rates, a procedure all to the benefit of traders. In short, it is not too much to say that the term of "Traders' Charter" which was given to the Railways Act of 1921 is abundantly justified. Not only do they have the many advantages briefly alluded to in the foregoing remarks, but they have the distinct impetus to co-operation with the railway companies of the knowledge that 80 per cent. of any surplus earned above the standard revenue shall accrue to them in lower rates and charges—or, on the other hand, in lower fares. From the viewpoint of the general public, it may additionally be stated that they will in the long run have the definite advantage of being able to use alternative routes on a far wider basis than formerly, and thus obtain the use of increased facilities.

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Aerial Transport Developments

A brief survey of progress made, and future possibilities, viewed primarily from the traffic standpoint, and indicating other channels of usefulness for the airway.

IN the *Manchester Guardian Commercial Annual* Review of Trade, Transport, Industry and Finance for the year 1923, the section dealing with Aviation commences with the following striking paragraph:—"For Britain the most important aeronautical event of the year was the inauguration of a service between Manchester and London." To the uninitiated there might not appear to be anything of particular importance in that announcement, but when it is remarked that between Manchester and London, roughly 185 miles distant by rail, there are excellent railway services by several lines which convey passengers between the two points in a little over 4 hours, it will doubtless be appreciated that if an air service can prove popular on such a route, there are tremendous possibilities even within the boundaries of a relatively small country.

This inland service, which was started in October, 1922, by the Daimler Air Line, has attained remarkable success; in fact, in one particular week, the passengers on this route were more than the total on all the lines between England and the Continent. No wonder, therefore, that the success of the London-Manchester route has definitely been heralded as the beginning of a new era in British transport.

So far as Europe is concerned, there can be no doubt at all that aerial transport is only at the beginning of a big contribution to the communication facilities. During last summer some remarkable records in passenger traffic were made. At the London Air Port, nearly 3,000 passengers were dealt with last August, as against 1,500 in July. The weight of goods conveyed by air is also steadily increasing, and as these necessarily are goods of relatively high value, it is not surprising that, with the help of the subsidy given by the French Government, the Compagnie Messageries Aerienne, which specialises in goods carrying, now makes a profit on the work. Additionally, this line performs a deal of mail-carrying work, especially in the South of France, and finds it quite a lucrative business.

An Expert Discusses Air Transport Progress

The general question of Air Transport was the subject of a lecture at the British Institute of Transport early this year. The speaker was Mr. F. Handley Page, than whom no one is more competent to deal with the question, and the paper was heard with great interest by a large gathering of members. Mr. Handley Page made it his primary business to deal with the development in air transport that had taken place since civil aviation between England and the Continent first started in August, 1919, and in dealing with the results achieved. His views are well worthy of summary, as they cover the character of the loads, the routes operated, the results of operation, the costs of the service, and probable future developments.

As to the character of the loads, this is essentially a case where passengers, parcels, mails and urgent articles of freight, each having a relatively high transport value, are to be encouraged, and to induce more to pass by air, it is fundamentally necessary to improve the ground organisation so that the total transit time is able to improve as much as possible upon that than by any other means. The delay involved in Customs clearance is a difficulty in this connection.

The routes at present operated by British companies are London-Paris, London-Brussels-Cologne, and Manchester-London-Amsterdam, while the French, having, as would naturally be supposed, more services, work the following main air lines:

Aerial photograph taken between Buxton and Matlock, Derbyshire

SOUTH.

Toulouse-Barcelona, through Spain to Casablanca, by the Latecoere Co.

NORTH AND SOUTH.

Paris-Brussels-Amsterdam, by the Compagnie des Messageries Aeriennes.

London - Paris - Marseilles, by the Compagnie des Messageries Aeriennes.

Paris-Lausanne, by the Compagnie des Grand Express Aeriens.

EAST.

Paris - Strassburg - Prague - Warsaw, by the Compagnie Franco-Roumaine de Navigation Aerienne.

Paris - Strassburg - Prague - Budapest - Constantinople, by the Compagnie Franco-Roumaine de Navigation Aerienne.

With regard to the cost of air services, Mr. Handley Page wisely observed that while air transport, to be successful, must not be too expensive, a higher price can be obtained owing to its high speed of transit. When the service is small, the largest portion of the cost is the overhead and general establishment charges, which cannot be reduced below a certain amount. The capital of an air transport company is mostly invested in machines, engines, and spare parts necessary for the efficient conduct of the service, and it is essential, if the unit expense is to be cut down, that the equipment used should be the maximum amount possible. It is obvious that aircraft should be kept flying continuously in the service, with no time on the ground beyond that necessary for inspection, adjustment, or overhaul. There are, however, limits upon such a system of operation, owing to night flying being as yet impossible commercially. As the services expand, so, however, will the overhead charge per passenger or lb. freight decrease, and great improvement is to be expected upon these lines.

Dealing with probable future developments, Mr. Handley Page stated that if, as is really necessary, civil aviation is to run on its own feet, without subsidy, the first necessity is the expansion of services so as to reduce overhead charges per passenger or per lb. of freight. There is also ample scope for improvement in the machines. To-day the average covered aircraft carries between 15 and 17 lb. for every horse-power installed, and of this, at the outside, 4 to 5 lb. per horse-power is the paying load. The cruising speed varies between 85 and 100 miles per hour. It should not be impossible within the next few years to increase the total carrying capacity for the same top speed to, say, 25 lb. per horse-power, and obtain a useful load of 10 lb. per horse-power. If this were done, the cost per ton-mile would be reduced to 1/6 for the full load. In conclusion, Mr. Handley Page stated that the necessary basis for commercial air operations had been thoroughly tried out in these few experimental years, and it only needed the necessary support to be forthcoming for the extensions of the routes to be opened, and the great Imperial air route to the East to be started.

View of a town planning scheme showing main traffic arteries

A Commercial Route to India

In this possible development India is particularly interested, and it is worthy of record that in the final report of the Civil Aviation Advisory Board on Imperial Air Mail Services, recently published by the Air Ministry, the proposed Imperial air route to India receives considerable attention. It is not very long ago since Major-General Sir William Brancker, Director of Civil Aviation, stated that Imperial value of air transport was going to be enormous, and that when night-flying developed, they would be able to arrange communications by air with India in 72 hours.

With regard to the air mail for India, the report to which I have referred points out that there are three main routes which an air mail service might follow on its journey. The three routes are, respectively, *via* Egypt, *via* Constantinople, or *via* Alexandretta. The first would make use of the R.A.F. route from Cairo to Bagdad, and is therefore considered capable of more immediate operation by a commercial undertaking. The second route, however, gives the most rapid line of direct communication between Europe and India, but it must be some time before such a route can be regarded as a practical proposition. A route, 1,145 miles long, between Constantinople and Bagdad, is suggested. For the next link in the chain, Bagdad to Karachi, a route down the Persian Gulf *via* Bushire and Bunder Abbas, is outlined, 1,650 miles in length. From Karachi, on the advice of the General Post Office, there should be a 550-mile feeder line to Bombay.

It should also be noted that the Advisory Board recommended that a sum of £200,000, spread over three years, should be set aside for technical investigation. Of this sum, £100,000 should be devoted to preparing the Bagdad-Karachi stage, and £20,000 for the route from Cairo to Bagdad. Tenders should be invited for weekly and daily services between Cairo and Bagdad, and Bagdad and Karachi. The company whose tender was

View showing the railway, an overbridge and adjacent property

accepted should receive an annual payment for three or five years in consideration of the services rendered to the Empire, and a guarantee for five years of interest on the capital invested.

The Possibilities of Aerial Photography

Another important development possible now that air communication has established itself, is that of surveying, or mapping, from the air. Already most magnificent work has been done, and in remote lands, where the ground is imperfect and surface communications are deficient, aerial photography must be of extreme value. "Preliminary survey of the routes for new railways and roads, or for the approaches to possible harbours, and prospecting of all kinds, provide plain opportunities," says a recent leader in *The Times*, and from the information I was able to obtain on a recent visit to the works of a leading aircraft company, I unhesitatingly agree.

Value of Photographs

It is unnecessary to enter into detailed particulars of the methods employed, but the accompanying illustrations will show how clearly the aerial camera is able to distinguish and record everything that could be desired by the most fastidious. The general possibilities are too obvious to require any elaboration, but it may be said that for any class of surveying work, in connection with establishment extensions, or as indicated above for the ready reproduction of pictures which are better than plans, and also for a novel and valuable form of advertising, aerial photographs are of extreme value. A special process is used, as would be supposed, but the result is to give an undivided picture, if such be required, of the area surveyed, and one that gives "life" to a subject that in diagram or plan would be "dead" to the average man.

Other Developments

A final word. Just as aeroplanes during the Great War were used to drop death-dealing substances, so for the purposes of peace they may be utilised to drop substances that make for death—and life. Quite recently, in America, they have been used to fight the Boll-weevil, one of the deadly enemies of the cotton-grower. Aeroplanes flying low distributed poison-dust over from 250 to 1,000 acres per hour at an incredibly small cost, and the result was found to justify their employment. In this, and in many other ways, the new form of communication has justified itself, and, as improvements are made, organisations are strengthened, and the public are educated to the advantages of air communications, both for passengers and certain classes of freight, so will the air industry develop, and bring about its epoch-making contribution to a fuller degree of maturity.

INDUSTRIAL SCIENCE

(*Continued from page* 522.)

time to the study of the subject. It is said that at the church at Pisa one of the most important incidents of his life occurred. No doubt tired with the service, he proceeded to amuse himself by watching the swing of a lamp suspended by a long rope from the dome of the church. He found by comparing its pulsations with the rate of his own pulse, that there was a law associated with the length of the rope. He must have encouraged the swing of that lamp somewhat, for he found that whether the swing was small or large within the limits he tested it, that there was no variation of pulsation.

No doubt hundreds, perhaps thousands, of people had seen that lamp slowly moving from side to side, but it remained to Galileo, with his ability to reason out such things methodically and scientifically, to recognise in the simple fact a fundamental discovery concerned in the principle of the pendulum—nature's most perfect instrument.

He afterwards proved that the prevailing opinion was wrong which taught that a heavy weight fell through space quicker than a light one.

It must be evident, therefore, that if India is to become a leading industrial nation, her people must also take an advanced place in the development and research into the details of her various productions and natural resources. They must adequately take hold of these things which, by her geographical position and their knowledge of the peculiar native requirements, places her in a more favoured position to supply not only for themselves, but also to nations less favoured in producing them.

There is no limit to the potentialities of the minds who scientifically grasp the present-day facts of industrial India, and who seek to advance the lives and occupations of the people, and to develop more advantageously the infinite wealth of the country.

Indian Railway Developments

In this article the author summarises some of the more important factors relating to India's railway development

IN the annual statistical number of the *Railway Age*, there is an instructive article which outlines in brief some of the railway developments in India during the year 1922. Many of these have been remarked upon in previous issues of INDUSTRIAL INDIA, and it need therefore only be said that while it is of extreme interest to know that many varied schemes are on foot for improving the transport position, the real need is for their speedy realisation.

That the Indian railways are managed and operated under circumstances of considerable difficulty, is a fact admitted by all having any knowledge of the conditions. Due allowance must, therefore, be made for this in commenting upon, or criticising, their methods. Like the railways of nearly every country in the world, the Great War exercised a retarding effect upon development, and it is only now, some four years after the conclusion of the so-called peace, that there is real opportunity for any extensive improvements. But such generalisations lead us nowhere in particular. Let me then get right down to the subject, and say that in my opinion the four most important developments in India are: (1) the decisions made as a result of the consideration of the recommendations of the Acworth Committee, (2) the appointment of a Chief Railway Commissioner, (3) the reorganisation of the operating departments on the Great Indian Peninsula Railway, and (4) the decision to continue the wagon pooling arrangements. In singling out these four aspects for special consideration, I am not unmindful of the many other important phases of development work that are proceeding, but from the nature of things it would be impracticable to deal adequately with the circumstances involving line and yard extensions, station enlargements, and other improvements—and it might also be added that I have commented upon the most important in previous articles.

First Electric Suburban Train to leave Euston after Electrification of London Suburban lines.

The Acworth Committee's Recommendations

While numerous Commissions have in the past attempted to deal with the Indian railway problem, it can, I think, hardly be denied that the commission of ten members presided over by Sir William Acworth, K.C.S.I., which investigated the conditions in India during 1921, has done most good. The report of that Committee was a formidable document, and one that was at the same time condemnatory and appreciative. An enormous volume of evidence was taken, and from this the railway system of India was denounced as wholly inadequate to meet the industrial, commercial, and agricultural needs of the country. Many illustrations were given to indicate the appalling waste that occurred owing to the paucity of railway communications, and the report plainly stated that unless the problem was tackled at once, and on extremely broad lines, there was little or no probability of improvement in the future.

One of the great obstacles to the effective development of railway transportation was the question of financing new works and improvements. As the railway budget was associated with the general budget of the country, difficulties of a national character involved a shortage of funds for railway purposes. Added to this was the ridiculous system under which funds voted for railway purposes lapsed under certain conditions. The Acworth Committee tried hard to untie this knot by recommending the entire separation of the railway budget from the general budget, and while this recommendation has not been accepted, there can be little doubt that it was their insistence upon the necessity for definite and regular allotments of railway funds that led to the raising of a large loan earmarked for railway purposes during the next five years.

The importance to the railways of having this definite sum cannot be over-estimated. In the circumstances,

it will be of incalculable advantage, and as the companies are going ahead with the spending of the money on much-needed new works, on new locomotives and wagons, and on the many other great needs, the Indian railway position is now well on the way to improvement.

The Appointment of a Chief Railway Commissioner

The appointment of Col. Hindley, Chairman of the Calcutta Port Commissioners, and a former Agent of the East Indian Railway, as Chief Railway Commissioner for India, marks another step in the upward progress of the railways. The old method of control, under which the Railway Board, comprising a President and two members, were responsible to the Viceroy through a Member of the Council who had general as well as railway duties, was thought by the Acworth Committee to be totally unsuited to the needs of India, and they recommended not only that there should be a separate member of Council for communications, but that the future head-quarters establishment of the Indian Railways should comprise a Chief Railway Commissioner and four assistant commissioners, each with a defined area.

The new Chief Commissioner assumed office on November 1st, 1922, and has the not altogether enviable task of reorganising the overhead railway supervision. Above all things he will have to pay special attention to the general transportation arrangements. According to the report of the Acworth Committee, insufficient attention had been paid in many quarters to the possibility of effecting great improvements by relatively small alterations, and it is considered that the development of an organisation having greater experience in operating problems will prove of sound advantage.

Many important points of policy have also to be settled as between the Government and the railway companies, and the new Chief Commissioner, after he has had time for detailed investigation, is expected to be called upon to advise the Government upon these matters. Another point is that there has, apparently, not been as close a form of co-ordination at head-quarters as is considered desirable, and one of Colonel Hindley's duties will be to instal a supervisory organisation working intensively and co-operating for the best results.

Model of proposed New Station showing Booking Hall at top and Escalators and Steps leading to Platform

Re-organisation of Operating Departments on the Great Indian Peninsula Railway

It may at first sight appear somewhat peculiar to place this reorganisation among the four most important recent developments on the Indian Railways. But as one whose whole experience has been in railway work, and who has acquired a comprehensive insight into the activities of all departments, I am convinced that the best operating organisation for any great railway is the division of the work into the three sections: Transportation, Commercial, and Mechanical. The reorganisation of the Great Indian Peninsula Railway was adopted after the authorities had considered a most valuable report compiled by Mr. D. S. Burn, General Traffic Manager, who, in order to ascertain the best practice, investigated the conditions in England, in America, and on the Continent. His recommendations may be said to be a compromise between the best British and American practice, though it is significant to add that in England, the tendency under the grouping arrangements is still more closely to follow the scheme adopted on the G.I.P.

In brief, the change is this. Instead of a purely Traffic and purely Locomotive department, the Traffic is separated into Transportation and Commercial departments, and the former takes over from the Locomotive department the control of locomotive running. This is essentially sound practice. The main duty of a railway is to run trains and to carry as much traffic as possible in the quickest possible way. Hence the need for placing the whole of the movement in the hands of one officer. Nowadays the reorganisation scheme came into effect on November 1st, 1922—one department is concerned with getting the traffic and dealing with questions involved therein; another is solely engaged in moving and handling the traffic, and the third finds its exclusive duty in providing the power as required. An additional advantage in the reorganisation was the enlargement of the area of control. Instead of the previously existing (relatively small) districts, a divisional scheme was adopted—this having many points of merit from the administrative aspect.

Wagon Pooling to be Continued

The decision made last October at the Indian Railway Conference to continue the general wagon pool for another three years is an extremely important development. It is known that some companies, notably the Bengal-Nagpur, were averse to a continuance of the pool for the reason that their wagons were not receiving proper attention on other lines, and that they were being compelled to utilise wagons that were not only unsuitable, but in many respects defective. This question of wagon repairs is a difficult one, and the responsible officers are busily engaged in trying to evolve a more satisfactory scheme. Taken all in all, however, it would have been little short of disastrous if the pool had been terminated. Even the most convinced opponent of pooling will admit that the scheme of common-user enables a greater loaded wagon mobility to be obtained, and as this is the determining factor when there is an admitted shortage of rolling stock, as in India, that consideration alone justifies the pool. In connection with wagon stock, it may be added that the Indian Standard Wagon Committee have recently tabled recommendations as to the future wagon to be adopted for certain purposes, and if these are adopted, the difficulty of repair work should be minimised in due course.

Other Developments

There are many other points of interest to which reference might be made, but considerations of space prevent any elaboration. In connection with passenger traffic operation, the extension of the train control system and the introduction of articulated carriages on the Great Indian Peninsula Railway is interesting, and I heard recently that quite a number of these carriages are to be built for service on other Indian Railways. Of similar utility in connection with passenger traffic are the standard composite carriages recently introduced on the Bombay, Baroda, and Central India Railway. One of these carriages was sent to the Locomotive and Carriage Superintendents' Conference at Lucknow last year, and very favourable remarks were passed upon its appearance.

Finally, reference may be made to the constant work going on in connection with the strengthening of bridges, in order that heavier trains may safely negotiate the sections affected. Much work of this description has been put in hand on the East Indian Railway, while as a corollary to the desire to work lengthy freight trains, experiments have recently been conducted on the G.I.P. and other lines in connection with the continuous brakes. In an early issue I propose to deal specially with this matter, which is one of great moment in considering the freight traffic problem of the Indian Railways.

In a short time the Administration Report for the year 1921-22 will be available, and I shall then hope, as in previous issues, to contribute the usual article summarising the progress made during the year, and outlining developments and possibilities.

The Tractor as an Aid to Agriculture

A brief description of the way in which the motor vehicle is utilised for agricultural purposes in the United States—and a pointer for developments in India.

IT was remarked in London the other day that transport in all its forms had developed to a greater degree in the United States than in any other part of the world, and had, in fact, been the main factor in extending American trade and commerce. While one might join issue with the claim for superiority in this direction, it cannot be denied that transport has been cultivated, and directly applied, to its many varied purposes on a wider basis than is general in other lands. Marvellous strides have been made in connection with motor traffic in the streets of American cities, and almost equally great are the important developments in the utilisation of the motor vehicle for agricultural purposes.

In India, where agriculture is, and must long remain, the principal support of the multitude, and also in England, where, for one reason or another—but largely through ignorance—the tendency has been backwards, the utilisation of labour-aiding and revenue-earning machines for agricultural purposes has not become really popular. Yet proof exists of the wonderful value of such machines, and it is really astounding in these times that old methods should be able to withstand the onward march of progress. It is interesting to contrast the conditions in two countries offering somewhat similar conditions. In the United States, where motor traction is employed on almost every little holding, a reversion to the farm horse or to oxen would be unthink-

Avery 12-20 H.P. Tractor ploughing with three furrow 14" mold board plough

able. On the other hand, there has been a tendency in this direction in England. The reader will inevitably ask, "Why?" And I reply by quoting a writer in a London contemporary that power machinery did not get a fair chance, because, as he pertinently puts it, "farmers bought tractors and vehicles . . . without due consideration of the suitability of the work to the machines and of the machines to the work; many who acquired three-tonners had not the work to justify the expense of such a large vehicle--or, if they had the work at the time, there was no guarantee that it would be permanent."

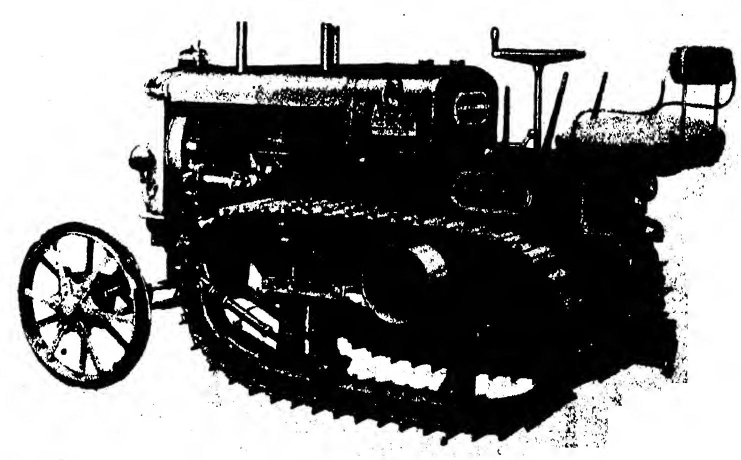
Machinery for Agricultural Work in America

They manage these things better in America. There the various companies engaged in the manufacture of farm tractors specialise in the "right size tractor for the right size farm," and special instruction is imparted as to their use and construction. Every aspect of farming, it would appear, is considered and provided for by the astute maker of motor vehicles. Row crop cultivation and all kinds of field and belt work are catered for. Threshers are built in sizes, "to fit the needs of any individual farmer, or custom threshing," as an American catalogue, now before me, tersely expresses it. Special attention is devoted to the production of tractor tillage tools to operate with a farm tractor. The Avery Company, of Peoria, Illinois - some of whose specialities are depicted in the accompanying illustrations - is a case in point. They specialise in motor cultivators, tractor "plows" and grain threshers, and are one of the biggest concerns of the kind in America. What they do not know about tractor ploughs is certainly not worth bothering about.

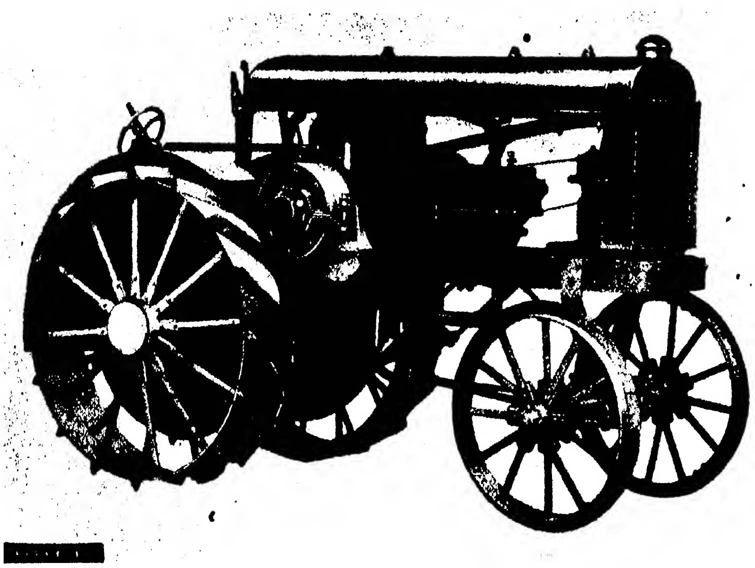
"Avery" Agricultural Machines

The Avery track runner, which pulls three 14-inch ploughs, is the very last word, as the saying is, in vehicles of the kind. It figures among the accompanying illustrations. The overall width of the track runner is 48 in.; the overall length 9 ft.; and height 58 in. The weight, without the forecarriage, is 4,500 lb., and with the forecarriage, 5,000 lb. Its turning radius is substantially its own length—a very important consideration. It rides smoothly over the rough ground, and can be used with or without the front wheel, which can be detached in two minutes and attached in three. The motor has a bore of 4 inches and a stroke of 5½ inches; its cylinder walls are renewable, and its crankshaft is 2¼ inches in diameter. The fuel used is petrol, kerosene, distillate, or alcohol, but it must be mentioned that in the case of the last-named, special compression is required. The capacity of the main fuel tank is 30 gallons. The track runner is specially protected from dirt and dust, and is automatically lubricated.

A special feature of the machine is that the whole of the wear falls on the parts that are cheaply replaced. As Mr. E. M. Voorhees, Manager of the Export Department, remarked: "We find it a very great advantage to be able to put on the two front wheels, or leave them off, as desired." In straddling ridges the wheels are an absolute necessity, and, for ploughing, the front axle is set over until the right-hand wheel drops into the furrow, thereby acting as a pilot guide. The track runner is equipped with a big, wide, comfortable seat,



Avery three-plough Track Runner



Avery 12-20 H.P. Tractor

has a self-starter, electric lights, and everything that could be desired in a machine for agricultural purposes.

Messrs. Avery's 12-20 h.p. tractor is another useful tractor, and invariably develops more than its rated horse-power. It is a four-cylinder motor with 4½ in. bore and 6 in. stroke. The tractor is very fully equipped with ball bearings, and all gears are enclosed and run in oil. It has all the regular Avery features, including the Avery "draft horse" motor and "direct drive" spur gear transmission, together with many and improved features.

Utility of the "Avery" Machines

The Avery Company have undoubtedly done excellent work in developing these machines, which should be of the greatest utility in India. It is claimed that these particular machines can more than hold their own with any others of the kind manufactured in America and that is almost as good as saying "manufactured anywhere in the world." In this connection, Mr. Voorhees, to whom I have previously referred—and who really ought to know—has stated: "In our judgment these two models may be the ultimate tractor for the average farmer. There have been a great many small tractors sold. We have been building them ourselves, and for orchards, vineyards, and truck patches they are all right, as there is not much invested in them and they can do quite a lot of work. But there is no comparison between ordinary tractors, and the two types described for a farmer who possesses a hundred acres or more. He wants a machine that will handle three ploughs under hard circumstances, and be big enough to drive a good-size thresher or saw. . . . Even on large farms people are finding that in many cases it is better to have a few medium-sized tractors, rather than one very large machine, for the reason that, when anything happens to the large tractor, everything stops, and it can only do one kind of work at one time, whereas with two or three medium-sized tractors various operations on the farm can be going on simultaneously."

Development Necesssary in India

I have dealt with this question of utilising machine-power as an aid to agriculture, because I am convinced that there is real need for extensive development in this direction throughout India. In these times, manual or animal work is quite out of date, and even where the holding of one individual is insufficient to warrant the exclusive use of machinery, a little co-operation in the use of tractors and other agricultural appliances would tend to the common gain. Of course, the conditions in India are fundamentally different from those operative in many other lands, but with the growth of Indian industries, the tendency will be for these conditions to be levelled up, and it will then be imperative to have recourse to machinery to aid manual labour. Be that as it may, there can be no possible shadow of doubt that more machinery than is now used should be introduced for agricultural purposes, and it is in the hope of stimulating this important development that I have written this article.

Avery Track-Runner pulling three furrow 14" mold board plough

Railway Coachbuilding in India

A brief description of a handsome and commodious saloon built at the Kanchrapara Works of the Eastern Bengal Railway for the use of His Excellency the Governor of Bengal.

A NEW special saloon for the use of His Excellency the Governor of Bengal has recently been turned out of the Kanchrapara workshops of the Eastern Bengal Railway, where it has been built to the designs and under the supervision of Mr. H. H. Spalding, Locomotive and Carriage Superintendent.

The saloon, which is built for use on the metre gauge, is depicted in the accompanying illustrations showing exterior and interior views. It is carried on two six-wheeled bogies, and is 57 feet in length over the mouldings. The length of the underframe is 56 ft. 6 in. The main saloon is panelled with teak, and the furniture is of padouk, polished mahogany, while the racks, curtain rails, etc., are of antique silver finish. A deep green carpet covers the floor. The exterior of the saloon is finished in white enamel and lined in gold.

Interior of Special Saloon

Upholstery

Dark green morocco hide is the colour used in the upholstery of the coaches and chairs, while the curtains and lamp shades are of dark green silk, the whole scheme giving a restful and pleasing appearance. Electric lighting on the Stone system is employed throughout the coach, and the electroliers and brackets are of antique silver finish to harmonise with the other fittings. The fans are so arranged that a constant stream of cool air circulates throughout the saloon.

Altogether the saloon is an especially pleasing example of Indian workmanship, as will be seen from our illustrations.

Exterior of Special Saloon

One of the simplest methods of raising water from open wells is to hang an endless chain from a pulley into the water and rotate the pulley. The ascending part of the chain catches water as it rises and carries it to the top. The efficiency of this method depends very largely on the design of the chain, and a leading British firm recently brought out an improvement whereby the "chain" consists of a series of strips of aluminium alloy bent in the form of triangular cells and carried on a flexible belt.

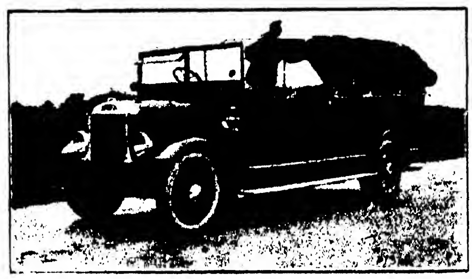
Some Useful Motor Vehicles

A brief illustrated description of five Leyland models that have proved highly satisfactory in service.

All Illustrations are by courtesy of Messrs. Leyland Motors Ltd.

THERE are few motor manufacturers in the world with so high a reputation for the excellence and reliability of their products as the famous firm of Leyland Motors Limited, Leyland, Lancashire, England. Founded in the year 1895, this firm soon began to enter vehicles in competitive trials, and was successful in obtaining several important awards. In the celebrated trials held by the Liverpool Self-Propelled Traffic Association, a Leyland motor vehicle was awarded a first prize of £100, and in the Liverpool trials of 1901, a gold medal the highest award fell to the Leyland Company. Other notable successes were those obtained in the first War Office Subsidised Vehicle Trials, held in November, 1912, when Leyland machines were the only vehicles awarded certificates of success. The proved utility of the vehicles will be manifest from the statement that during the Great War, over 6,000 military motors - a large proportion being the popular Leyland "G" type 4-ton Subsidy Model, were supplied by this firm to the Government.

It is worthy of notice that the name of the firm is taken from that of the small town, situated near Preston, Lancashire, where the orginal firm was established, and where the Leyland Company's property now exceeds 160 acres. In addition, the Company has extensive works at Chorley, a few miles from Leyland, these being devoted primarily to the production of fire engines and steam wagons; and also at Ham, in Surrey, are works acquired in 1920 for the specific purpose of reconditioning thousands of Leyland vehicles repurchased from the War Office after serving their military purposes.

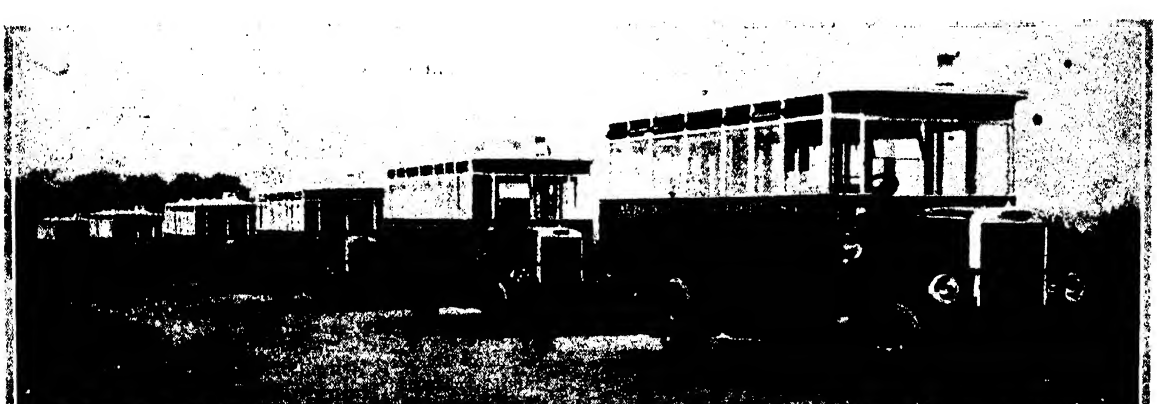


23 Seater Char-a-banc with special Fleetwood Hood

The Leyland Company has depots and agents in all parts of the world, the administration of the Overseas Department being concentrated at the London Office in New Kent Road, from which place all information relative to their motor vehicles can be obtained. The latest catalogue, thoroughly descriptive of the various models, is a splendid production, and of considerable value, apart from the special reason for its publication. All interested in commercial motor transport development should obtain a copy.

In this article we illustrate, by the courtesy of the Leyland Company, one type of single deck omnibus, a 5-ton standard lorry, a 500 gallon fire engine, and a char-a-banc. Of course, the Company builds many other classes of commercial vehicles, and apart from the models illustrated, they manufacture a wide variety of general vehicles for municipal and other forms of transport work.

The single-deck omnibus and the large char-a-banc touring car are typical and popular types of vehicles for their special class of work. In both cases their use is rapidly being developed, in the first case as an essential link in the transport of



Fleet of Buses for Spain, 40 Seaters, 40-48 H.P Engines

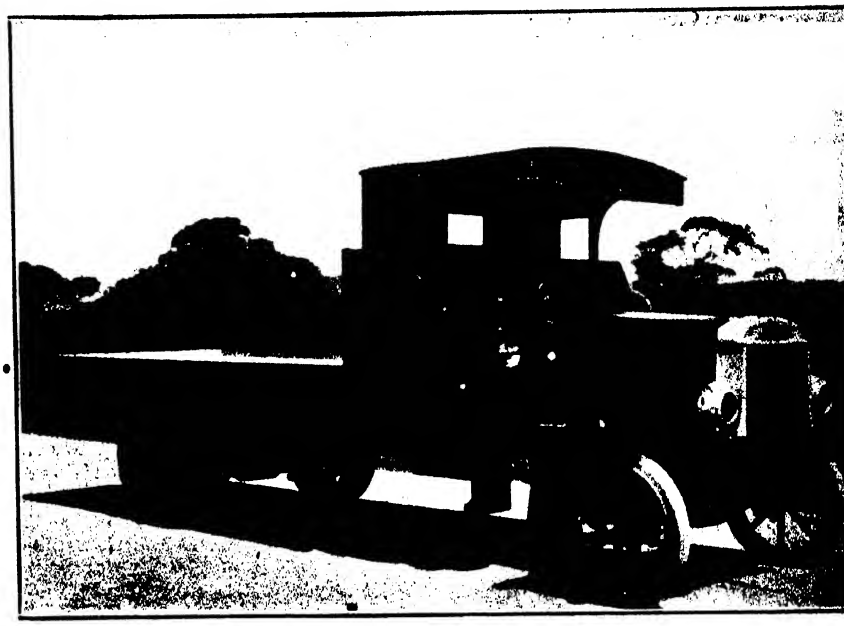
many districts inadequately served by railway, and in the second for holiday and trip work. The single-deck omnibus is designated the "A5" model. The chassis is fitted with a 30-32 h.p. engine with worm driven rear axle, the wheel-base being 11 ft. 9 in. Dunlop super-resilient tyres are fitted, and the vehicle is built to carry eighteen passengers. It is painted maroon and cream, or as otherwise ordered, and the vehicle illustrated is one of several now working successfully in the Potteries district of England. It might incidentally be added that in Edinburgh, where they are slowly converting a slow and unreliable cable tramway service into an electrically-operated service, a large number of Leyland vehicles have been introduced to cover the transport needs during the period of conversion, and that they will subsequently be used to extend the area of the district served by trams and omnibuses from the centre of the city. The illustration, showing single-deck omnibuses, depicts part of an order carried out by the Leyland Company for work in Cordoba.

The large touring car, with a seating capacity of twenty-three, is of a type growing increasingly in favour. Designated model "C1," the chassis has a 30 h.p. engine, worm-driven back axle, and four-speed and reverse gear box. It will be noted that the illustration shows the operation of fixing a patent hood over the car. It has been a matter of difficulty to find a suitable covering, and one that could swiftly be introduced when circumstances necessitated this. Leyland Motors Ltd. have, however, successfully overcome the difficulty, and have devised a hood which can quickly be raised or lower as desired.

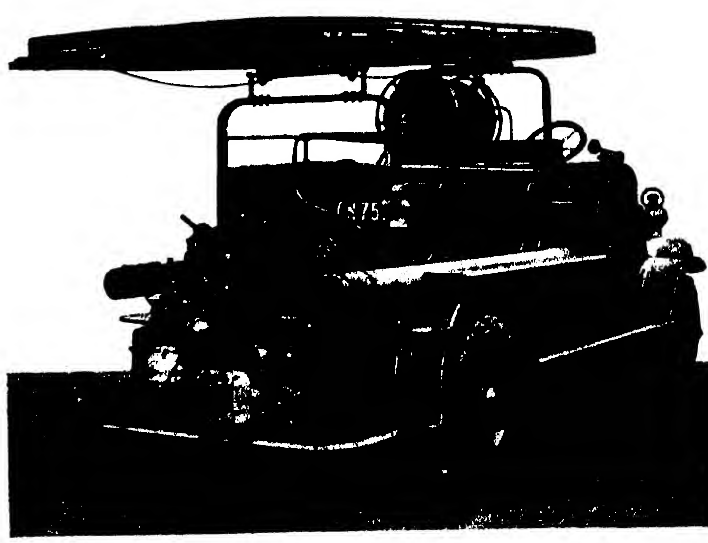
Turning to commercial goods vehicles, the "P2" 5-ton standard lorry illustrated is one that has been adopted on a wide scale. It has a 40-50 h.p. engine and gear-driven back axle. It is supplied complete with separate driver's compartment, and is fitted with acetylene headlights. The platform is 14 ft. 6 in. long and 7 ft. wide, and, as will be seen, is of a type generally used in heavy transport work. The vehicle shown is in the service of a large Manchester brewery firm, which essentially requires extreme reliability in service, and, it may be added, as illustrating the popularity of this type of vehicle, that many important firms have standardised their fleets of motor lorries on this basis.

The final illustration shows a useful type of motor fire engine which the Leyland Company has supplied to many municipalities. It is a 500 gallon fire engine, and has a 40-48 h.p. engine, fitted complete with Rees Roturbo pump. As will be noted, the vehicle is of a handy, compact type, and it is understood that it has been found very useful at Dolgelley, Wales.

It would, of course, be possible to to go on almost indefinitely, in description and illustration, to show the utility of the products of a famous firm. While, therefore, it is probable that the four types of vehicles illustrated will give a broad general idea of the Leyland vehicles, all interested should obtain the latest catalogue, which gives full particulars of many new models, and contains information relative to the enormous utilisation of Leyland vehicles in Great Britain, and, indeed, in all the countries of the world.



5 ton Lorry, 40-48 H.P. Engine



500 gallon Fire Engine 40-48 H P Engine

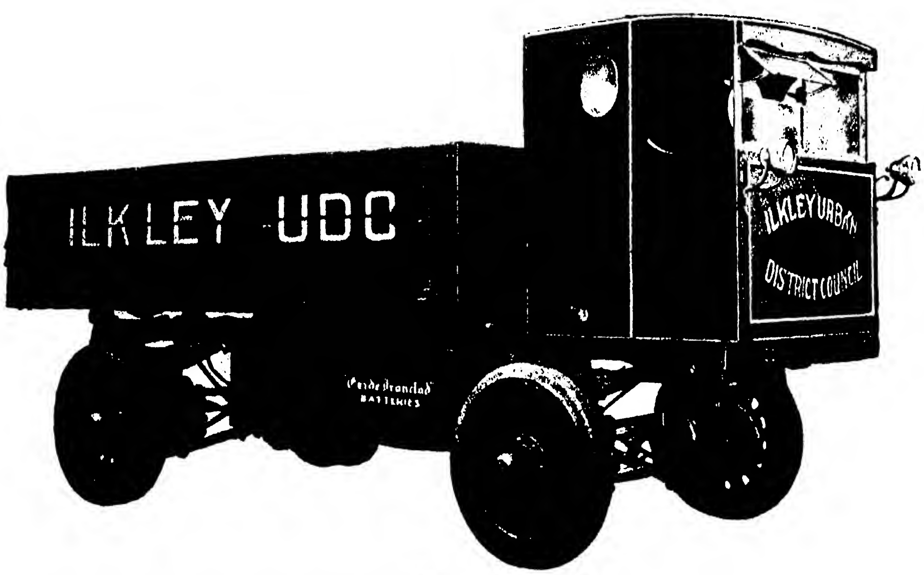
The "Exide Ironclad" Battery for Electric Road Vehicles.

AMONG users of commercial vehicles there still exists a prejudice against the electrically-propelled vehicle, despite the fact that this particular form of transport is everywhere winning golden opinions. Especially in connection with municipal work, for the purpose of large railway companies and important distributing houses, the electric vehicle is undoubtedly yielding valuable service, and the fallacy that it is unreliable should by this time finally have been exploded.

The early failures of the electric vehicle are, of course, responsible for the lingering belief that it is no good except for journeys of the briefest duration, yet the electric road vehicle has proved itself particularly convenient for internal town transport. This latter point was stressed by Mr. R. J. Mitchell at a recent meeting of the Institution of Electrical Engineers, though he frankly admitted that in spite of the simplicity of control and other advantages, it had not made the progress expected. Factors bearing on this are the high first cost of electric vehicles, the difficulties of charging, etc.

Much depends on the battery and the charging facilities. In this connection an enormous advance has undoubtedly been made in the development of the "Exide Ironclad" the "battery which saved electric traction from extinction"—as the slogan has it. The makers of the "Exide Ironclad," the Chloride Electrical Storage Company Limited, of Manchester and London, are pardonably proud of the fact that "there are more British-made electric vehicles fitted with this battery than are fitted with all other makes of battery put together." It is certainly well in evidence everywhere, and leading corporations and railway companies favour it. In the Hunslet goods station of the London and North-Eastern Railway, where horse-drawn vehicles were entirely superseded by electrically-propelled lorries, each lorry is fitted with a battery of 44 "Exide Ironclad" accumulators, having a capacity of 258 ampere-hours at a discharge rate of 50 amperes. The charging of the batteries is done during the night, six plugs being fixed in the goods warehouse and two in the garage.

As is generally known, the "Exide Ironclad" is a perfected form of the Faure accumulator, consisting of positive and negative plates immersed in an acid electrolyte. In older forms, and in "Exide" batteries made for other purposes, the positive and negative plates both consist of lead grids to which an "active material" has been applied in the form of paste. The "Exide Ironclad," however, embodies several radical departures from this type of battery. The accompanying illustration shows a useful tipping vehicle engaged in municipal work, fitted with "Exide Ironclad" batteries.



Tipping Wagon fitted with "Exide Ironclad" Batteries

New Petrol Electric Road Crane

Illustrations by courtesy of Messrs. Henry J. Coles, Ltd.,

We illustrate in this article a somewhat novel self-contained portable crane which has recently been put on the market by Messrs. Henry J. Coles Ltd., of Derby.

This new design has been evolved for handling loads up to two tons in an out-of-the-way place where ordinary cranes are not available, but where it is possible to drive a motor lorry. There would therefore appear to be a very profitable field open for this type of crane, particularly in a country like India, where large structural work is taking place, away from the ordinary facilities of a populated district.

This new crane is designed primarily for operating when the lorry itself is stationary, and not for transporting the load, by movement of the lorry on its own wheels. When it is required to transport a heavy load any distance, the load may be deposited on a trailer, and thence conveyd by the crane lorry to the spot required.

The design of the vehicle for heavy lifting is such that a solid connection can be made between the frame and the back axles, so as to keep a firm base for the crane to operate, and this explains the reason for the limitation in not being able to transport a very heavy load as a self-contained vehicle.

Crane in travelling position

The crane itself, however, is capable of swinging in a complete circle.

The chassis of this vehicle is the standard heavy 4-ton Tilling-Stevens petrol electric type, which is, of course, well-known.

When the engine of the lorry is operating the crane, it is found that it is only necessary to run the engine at half-speed, so a governing arrangement is fitted for this purpose, and the same apparatus acts automatically when the crane is at work.

The design of the crane itself is of Messrs. Coles' standard single-motor type, and is capable of lifting 2 tons at a radius of 10 feet and at a speed of 20 feet per minute ; that is to say, on a two part purchase, but when a single rope is used, half-load can, of course, be raised at double speed. The hook is capable of rising some 8 feet from the ground, and, as stated above, the crane can be rotated in a complete circle.

All of the crane movements are carried out by means of a 4 h.p. series-wound motor, by the General Electric Company, supplied with current at 110 volts from the dynamo of the chassis of the vehicle. The motor is fitted with the usual type of drum controller, and a special switch is fitted which automatically trips the main cut-out should the main jib exceed its limits of movement.

Another interesting point regarding this unit is the fact that it can be controlled by one man, which, in addition to being a self-contained portable apparatus, makes it one which is very economical to operate.

Crane in operation

Witton-Kramer Electric Truck Crane

Crane at work — The General Electric Co. Ltd

In every works and warehouse there are always instances arising of loads which have to be lifted and transported from positions that cannot be reached by any of the ordinary hoisting appliances. The steam or electric yard crane is generally limited in its radius of operation by the tracks on which it travels, and these usually serve only main arteries, whereas overhead cranes and runways are usually confined to the shops.

The electric truck has solved the difficulty of power transport between remote points, and a further development is the electric truck crane built not as an accessory to the truck, but designed throughout as an electric travelling crane. With a machine of this description, loads, wherever they may be, can be picked up and deposited, and the crane can be moved rapidly to any spot where a sudden necessity arises for a load to be handled quickly.

The "Witton-Kramer" crane illustrated is of the two-motor type, one motor being used for propelling the crane, the other to operate the hoisting, slewing and derricking motions clutches being utilised to transfer the drive to the desired motion.

The crane is capable of lifting a load of one ton at a radius of 10 feet, and at a speed of 20 feet per minute. It slews at 3 r.p.m., and travels at 4 miles per hour. The arrangement is such that all motions, including travelling, can be operated from the driver's platform with the jib directly in the line of travel.

Electric or mechanical brakes are fitted to all motions. The battery is built into the truck, and is of sufficient capacity to supply the crane for six hours without recharging.

Steam Storage Battery Locomotive Supplied to the City of Leicester Central Generating Station

This note refers to the locomotive illustration in our February issue, where we describe the new Leicester Generating Station.

By courtesy of the English Electric Co. Ltd.

This locomotive is provided for shunting purposes. It is capable of hauling 165 tons on a gradient of 1 in 40 at 160 lb. steam pressure. It has no fire-box, tubes, smoke-box, or funnel, and is fed with live steam at a charging station. The steam is lead from "Babcock" boilers at 200 lb. pressure measured by Kent meter, reduced to 160 lb. pressure and lead to a charging column situated outside the boiler house entrance. With one charge of steam the locomotive is capable of full work for approximately five hours. The recharge takes about ten minutes. The cylinders are 15 in. diameter by 18 in. stroke, and the locomotive is carried on four 3 ft. wheels coupled. The wheel base is 5 ft. 6 in., and the gauge is the standard 4 ft. 8½ in. The locomotive is fitted with a powerful hand brake to act on the four wheels.

Industrial Science

IT would be extremely difficult to find an industry which would not be the better for a reasoned analysis of its fundamental working for the development of that particular section of science which lies at the basis of its operations, and there ought to be a periodical overhauling of the grounds of its procedures if industrial developments are to be kept up-to-date, and production brought into greater prominence.

There are those who go still further and maintain that science has a function much beyond that which culminates in some particular industry. If we only approached the consideration of scientific subjects from the point of view of an effort to advance one particular aspect or one important phase of some industry, many secrets would go undiscovered.

From this point of view pure science must render considerable service to the improvement of many phases of our national, as well as our industrial life. It can readily be conceded that when it is pursued from the desire to obtain knowledge for its own sake, then we arrive at the highest condition of scientific research, for in the obtaining of knowledge the application of it follows as a natural consequence. No one can foresee the effect of a new aspect of an old discovery, or the development of a new discovery in science.

Nations are like individuals. Their first concern is the daily struggle for existence. Everything must give place to that one desire to be fed, to be clothed, and to avoid the discomforts of climate in the seclusion of home.

There are various standards of what constitutes a satisfactory solution of these problems. Some may be content with a brute-like grovelling in mean surroundings, with no desire to raise themselves above that level, but if material comforts are to be added to the desire to be fed and to be clothed, then it must come through the development of the mind and the desire for comfort and cleanliness.

This can only be obtained by the mind becoming so developed that it seeks out for some avenue by which that comfort, ease, and satisfaction is to be obtained, and early man thought that he could secure these advantages by predatory expeditions and pillage. But he soon found that a system of attack and possession did not lead to the comfort he sought; his mind reasoned out the consequences of these short-cuts to what he desired, and in that development he soon discovered that he must defend himself against reprisals and losses. Thus ultimately he was little, if any, better off than if he had depended upon his own efforts or upon the co-operative efforts of his fellows to obtain better conditions of existence.

Right through the ages, it has always been the same. His environments have forced him to think and to act in a way which will foster his commercial and industrial activity, and which will produce such things as will add to the comfort of himself and his fellows with safeguards for the use and enjoyment of the things produced. He has found out by experience and the exercise of his mental faculties that the material comforts, when obtained, can only be maintained and enjoyed when they are obtained worthily, and when they give opportunities for settled comfort not only for himself, but also for those of his fellows.

The knowledge, and its application to the processes of his private and communal life, has been attained by his mental development—his logical reasoning in the domain of science. He has found out that it is a duty to work, for, in doing so, he not only benefits himself, but he adds to the common stock of advancement in production, he also finds that he has an independence which, along with his fellows, gives him the right to live. Not only for the continuance of his bodily existence, but he has also assisted to the betterment of his mental and bodily health.

He finds, in effect, that the duties involved in this work engender the right to live worthily and the leisure to think rationally.

This leisure and thought, if well directed, ought to lead us to study nature, for with all the present-day science, it has not exhausted the discoveries hidden in the complexities of the natural forces which surround us. There is little doubt but that we are gradually becoming more acquainted with its conditions, and we no longer arrive at results by instinct or chance, but by judgment formed from reason.

There are forces in nature, mystical, physical and chemical, which are so far beyond us, that, with all our progress, may be likened to children playing with dangerous things of which we know little. We are like children playing around a strange circular object thrown up on the sea shore. The coastguard may be able to tell us it is a mine broken away from its moorings—washed up as an aftermath of war. Before he can reach it, one of our companions tampers with a "whisker," and at once there occurs an explosion, and the annihilation of all within its vicinity. If science had come along before the misdirected force of the innocent but ignorant child had been used, no

harm would have been done: the engine of destruction could have been made innocuous. The mistake was not in the mine, but in our lack of science and knowledge of its danger.

In the history of this world we are often discovering evidences of a bygone height of civilisation, proofs that knowledge existed, in certain respects far beyond some of our present attainments. It may not have been in the same channels of research, for it is obvious they could not have expanded on exactly the same rotation or sequence of development, but there have undoubtedly been periods of advancement, and then blanks, periods in which nothing is known, and then gradually a laborious climb up again into what we call civilisation.

What had happened to cause these silent, unknown periods? Was it the forces of nature let loose over the entire surface of the globe? some great cataclysm of fire or cold, poison or flood? or was it some unlucky amalgamation of the forces surrounding us maybe in the air we breathe, or in the constitution of the earth upon which we walk? It is possible that some child of science had touched the special amalgamation which was the "whisker" on the explosive shell of this world's laboratory of infinite possibilities, and, as a result, most of, or perhaps the entire globe was affected, and the civilisation of centuries disappeared, and, later, primitive man commenced again to develop, as if prior epochs never existed. Let anyone take stock of his entire habitation, and mentally calculate how much of what he owns—the everyday articles of furniture, personal treasures, pictures, hardware, silver, etc.—will be available for later centuries or generations to build up a history of our lives, our advancement, our loves, scientific attainments, luxuries, method of living, our work, and our aspirations generally. Probably nothing would be available to produce a connected narrative of our times. Our locomotives, ships, mechanical appliances and instruments may entirely disappear through the ravages of age without leaving a trace to show their use or that they ever existed.

This ought not to be looked at in a pessimistic, disheartening manner, but rather from the point of view that the greater the benefit, the greater must be the forces dealt with, and, when wrongly handled, the most dangerous, since the most dangerous elements are those most potent, for maximum efficient results.

The main point is knowledge, the organisation of common sense, which in its further developments means science, that which teaches the way how to treat, manage, manipulate, and know the idiosyncrasies of the subject treated, whether arrived at by way of applied science, or by pure science.

When subjects are approached by methods of pure science, discoveries may be expected which will direct new side issues or tracks of thought, and possibly may lead to the whole mental outlook of the community being entirely changed.

The effect on a community can only be the effect of the summation of individual thought, and a communal thought inevitably leads to national thought.

It will be found that pure knowledge forms the greatest hold upon the individual rather than the story of its application. It may be that the romance of first principles is held to be more attractive than the resulting mechanics to develop it; yet it must not be forgotten that the conclusions of science can only rest reliably on evidence of experience, no matter who may be the clever authority who may introduce the scientific original, and however attractive to the popular mind the aspect of pure original science may appear.

Science, like all other branches of knowledge, has certain fixed conclusions which may be termed dogmas based upon present knowledge, but in the nature of the case, when new knowledge is obtainable and recognised, then the fixed conclusions of the past must give place to newer knowledge, and fresh evidence may qualify the previous conclusions, and so alter the dogma of the previous position. If science has been based on true foundations, any new aspect will not destroy entirely the old interpretations, but it may shake them somewhat. If the old determinations have not overstepped what was the legitimate conclusion to be accepted from the evidence obtainable, then all subsequent knowledge will only clear away extraneous useless trimmings, and the main structure will not be weakened or destroyed.

Fundamental truth, truly accepted and conclusively proved by science, should always be above any suspicion of its being possible of being ultimately destroyed. Subsequent progress, in what might be considered a revolution of scientific discoveries, should only proceed in a constitutional manner.

On passing about the world in his daily vocation, or apart from his fellows, one will have frequently been impressed with the necessity of being well acquainted with many phases of general scientific knowledge.

He sees the blue sky above him, and if he has the true scientific spirit, he will ask himself, why is it blue? And he will not rest content until he has learnt that secret. He sees the ebb and flow of the tides, but how can he reconcile the slowness of their movement with the fact that the effect of the tides occur right round the world practically every twelve hours. He sees the barometer fall when bad weather or wind is approaching. Is it due to the atmosphere being light or heavy? How is it possible for twelve people to receive twelve distinct telegraphic messages through one wire; and, concerning the mysteries of wireless telephony, how can two people receive distinct conversation from a hundred miles apart through the same ether medium, and yet those messages are not destroyed, but remain distinct and independent of each other?

A man is occupied in building a locomotive, of steam-driven principle, and he wants to know how it comes to travel seventy miles an hour. If his study is to be of any value, he must not only direct his quest into the practical details of its mechanism, but he must be led up through certain elementary experiments which may appear to have no direct relationship with his present thirst for knowledge; the principle of latent heat, combustion, calorific values, pressure, expansion, and several other departments of drudgery. If these are neglected, he will not be in a position to look at the working of his engine scientifically, although he may be able to work it mechanically after others have prepared the instrument from their more advanced scientific knowledge.

The man who neglects this training and research may be an excellent labourer, or even an efficient automaton, but never a scientific leader.

Galileo did not at first know that he was gifted in his capacity to understand mathematics, he only became interested in it after leaving school by listening to a lecture on the subject. That lecture gave him such an impetus, that he devoted much leisure

(*Continued on page* 509.)

INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

Volume II MAY, 1923 Number 10

BETWEEN OURSELVES

The New Cahokia Station at St. Louis

Some further details are now available of the new Cahokia Electricity Station which is to be built by the Union Electric Light and Power Company of St. Louis on the south bank of the Mississippi. This station will be ultimately 240,000 K.W. capacity, and the construction has already been commenced of the first section of 60,000 K.W., the station being built in four independent sections. The general design provides for 0.65 square feet of ground space and approximately 56 cubic feet of building space for each K.W. capacity, and the site is well provided with both rail and water facilities for coal and ash.

After the most elaborate investigations lasting over two years, it has been decided to fire the boilers exclusively with the "Lopulco" system of powdered fuel, following on the satisfactory experience of the Lakeside boiler plant at Milwaukee, and the River Rouge plant of the Ford Company at Detroit, especially since low grade Illinois coal has to be used.

For this first 60,000 K.W. section the pulverising plant will consist of 8 mills working 16 hours a day, and pulverising enough coal in this time for 24 hours, the whole equipment being installed in a separate building next to the boiler house, individual mills having a capacity of 5-6 tons per hour. The drying of the coal before pulverising will be carried out in the up-to-date type of small driers which are a feature of the "Lopulco" system, using the exit chimney gases for drying purposes, whilst a considerable proportion of the transportation of the pulverised fuel will be by means of compressed air. It is expected that the nett working efficiency of the plant will certainly be over 85 per cent., and will probably be 87½ per cent., equal to that of the Lakeside plant.

The 60,000 K.W. section now being erected includes 8 water-tube boilers of the cross-drum type, 18,010 square feet heating surface, designed for 350 lb. pressure, corresponding to 300 lb. at the turbine stop valve, and with superheat temperature of 690 deg. F., each boiler being fitted with 10 "Lopulco" burners at the top of the furnace. The engineers designing the plant are of the opinion that what is termed in America "moderate size" units are the best, that is boilers of 18,000 square feet heating surface, at only 350 lb. pressure and at a temperature not exceeding 700 deg. F., together also with turbine units of 30,000 K.W. The furnaces are fitted with the most modern design of "Lopulco" water screen, to prevent slagging of the ash and corrosion of the brickwork, and sluicing methods will be adopted for handling the ash. The furnaces are of very large volume and capacity, so as to burn low grade coal at the highest efficiency. Economisers are not being installed, but provision is left for them, and also for induced draught, which, however, will probably not be necessary, and the object is to make the completed station one of the most efficient in the world.

Pulverised Coal Firing in Great Britain

The subject of pulverised coal firing in Great Britain was dealt with by Mr. J. S. Atkinson, of Messrs. The Powdered Fuel Plant Co. Ltd., of London, at a recent meeting of the Bradford Engineering Society. Mr. Atkinson gave the interesting opinion that British coal has a much higher average moisture content than American coal, and that the driers in Great Britain would therefore have to be of larger dimensions. Considerable progress, however, is being made in the invention of small and compact driers which use the heat in the flue gases, representing a great improvement both in convenience and economy, as compared with the ordinary large cylindrical drier heated by means of a separate coal fire.

The paper was, however, largely concerned with the "Unit" system of pulverised coal firing, in which the lecturer is more particularly interested, and it is stated that in Great Britain and on the Continent over 300 "Unit" pulverisers are now at work on all kinds of furnaces, although certainly very little progress has been made with steam generation.

As is well-known, the "Unit" system consists essentially of separate small pulverisers in front of each furnace, and the unit is composed of automatic coal feed, three or four pulverising compartments, and mechanically-driven fan, air being introduced through the feed inlet of the machine with a further supply of secondary air which can be pre heated if necessary. Such a "Unit" pulveriser will take lumps of coal up to 1 in. in diameter, and no drying is required as long as the percentage of moisture is not over, say, 12 per cent., which, of course, means, in practice, that nearly every quality of coal can be used direct. The percentage of moisture, however, affects the horse-power, but a typical figure for a "Unit" pulveriser, with coal

containing 8 per cent. moisture, is about 30 h.p. with one ton of coal per hour. The degree of fineness of the grinding of the coal is also not excessive, and the general severe figures in this connection hitherto used do not seem to be necessary.

Mr. Atkinson attaches great importance to the proper size of the combustion chamber, and the installation of what is practically balanced draught, so as to maintain only a very slight suction in the chamber and avoid anything in the nature of a blow-pipe action with the flame. The efficiency of the combustion is very high, averaging 16-17 per cent CO_2, and the chief difficulty, in fact, is to prevent the melting of the brickwork due to the high temperature with this efficient combustion. A lot of the trouble with the brickwork is caused, however, by incorrect design of the combustion chamber, too high velocity of the flames, and inferior fire-bricks, but Mr. Atkinson does not mention the recent invention of the water screen in America, which prevents "slagging" of the ash.

Some interesting details were given of the only large "Central" installation of powdered coal firing in Great Britain, namely, that at the Hammersmith Electricity Station. This installation is on the "Holbeck" principle, also supplied by Messrs. The Powdered Fuel Plant Co. Ltd., and has now been in operation for two years, having an output of 5 tons of pulverised coal per hour, and supplying one large "Stirling" boiler with an evaporation of 40,000 lb. of water per hour, and the plant is at present being duplicated.

* * *

The Low Temperature Carbonisation of Lignites

The question of low temperature carbonisation of lignite (brown coal) was dealt with specially by Professor W. A. Bone in his third and last lecture before the Society of Arts, on Lignites, and the gist of his remarks was that from a commercial point of view he did not recommend the low temperature carbonisation of lignites because our knowledge in this particular field was nothing like so advanced as in the case of ordinary coal. From a theoretical point of view, average lignite, with its large moisture and oxygen content, certainly does not seem to offer the same possibilities as average quality coal. Professor Bone is of the opinion, however, that it may eventually be a commercial proposition to partially carbonise lignites in order to increase and stabilise the quality of the fuel, especially in the way of removing moisture, whilst at the same time utilising any oils, ammonia, and gas that may be obtained in the process.

We understand that a small experimental carbonising plant has been erected at South Kensington, and interesting results have been obtained by carbonising various qualities of lignites at standard temperature of 705 deg. F., 930 deg. F., 1,290 deg. F., and 1,470 deg. F. Thus a Morwell lignite from the extensive deposits in Australia, now being developed chiefly as a fuel for steam generation, gave at 1,290 deg. F. 8.3 per cent. by weight of oil and tar, 9.1 per cent. of ammonia liquor, and 26.6 per cent. of gas, with 53.3 per cent. residue. Over 1,290 deg. F. the oil yield decreased heavily, due to "cracking."

One result of these experiments is, however, that if lignites are carbonised at comparatively high temperatures, say 1,560 deg. F., the whole of the objectionable oxygen content is got rid of, and a good residual fuel obtained, whilst it is interesting to note that the oils from lignite seem to contain a large proportion of hydrobenzenes. As regards the residual fuel, the most likely method of utilisation seems to be briquetting with 5 per cent. pitch, giving a valuable smokeless and free-lighting fuel, since there is still present, for example, about 15 per cent. of volatile matter if the carbonisation is carried out at 1,020 deg. F., the ordinary temperature for the low temperature carbonisation of coal, which gives a product of 10-12 per cent. volatile matter, with average 25-35 per cent. volatile coal.

* * *

The Burning of Cast Iron

Messrs. The International Combustion Engineering Corporation Ltd., from their new works at Derby, are just about to issue a most interesting brochure on the subject of the burning of cast iron, particularly as it affects firebars, whether for hand or mechanical firing. As the result of a number of years' detailed research work in their laboratories, they have been able to determine the chief cause of the trouble, and consequently to devise a new metal, "Usco" alloy, a special variety of cast iron with a much longer life. As is well known the life of a firebar is very erratic, and may be anything from a few weeks to over a year. The destructive action of the furnace consists of two distinct reactions, melting the iron, and burning it, that is slow combustion with oxygen to give various oxides. In practice, however, about 90 per cent. of the trouble is caused by burning.

A comparatively pure cast iron has a melting point of about 2,010 deg. F., but ordinary foundry iron contains, amongst other impurities, phosphorus and sulphur, which at the high temperature form phosphides and sulphides of iron, melting at 1,740 deg. F. In practice, therefore, an ordinary cast-iron bar, as soon as it reaches 1,740 deg. F., becomes brittle, and then the molten phosphides melt out, leaving a porous expanded mass of pure cast iron. This latter commences to oxidise rapidly at about 1,830 deg. F., although the reaction at a lower temperature, such as 1,470 deg. F., is very slight, and only about one-tenth as great. Consequently, when the firebars reach a temperature of 1,830 deg. F., the oxidation is much more rapid, because of the porous nature of the residual iron, the carbon in the iron being burnt first, so that the top layer of the bar is converted first into a purer cast iron, then steel, nearly pure iron, and finally iron oxide. Graphitic carbon and silicon also add to the difficulties of ordinary cast iron. There has hitherto been no practical method of overcoming these troubles. If the surface of the bars is chilled, this is soon lost at the high furnace temperature, a hard iron using a high percentage of scrap increases the impurities and tends to cause cracking, whilst a soft metal means an increase of graphitic carbon. Most special alloys hitherto produced have been found to present serious practical difficulties in the way of great expense, difficulty of pouring and of contraction, brittleness, cracking or other similar troubles.

The new "Usco" metal evolved as a result of this research is stated to have overcome these difficulties, to have a life from three to ten times as long as cast iron, with a higher melting point and tensile strength, whilst it is a thoroughly practicable foundry mixture which pours without difficulty and does not crack, so that any type of casting can be undertaken. The cost is reasonable, approximately 50 per cent. more than ordinary cast iron, although, of course, there would appear to be no comparison in the nett value.

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

The Manufacture of Armour-clad Switchgear

A brief survey of the facilities provided at the Hebburn-on-Tyne Works of Messrs. A. Reyrolle & Co. Ltd.

THE developments pending in all parts of the world in connection with railway electrification, and the ever-increasing extension of electric power supply to meet industrial and local requirements, naturally call for special equipments. The most important link between the generating station and the transmission cables, and between the sub-station and the network, is the controlling switchgear, and it is to the provision of this essential requirement that the firm of A. Reyrolle & Co. Ltd. has devoted its energies.

It was at one time believed that switchgear construction was a simple matter, involving merely the bolting to an enamelled iron framework of a few oil switches and their accessories. In fact, doubts were expressed as to the existence of any real engineering work in switchgear production. The works and products of Messrs. Reyrolle are sufficient proof of the fallacy of this idea. Reyrolle armour-clad gear complete in the assembly shops or erected in central or sub-stations shows a phase of British engineering at its best. It completes the work of the turbo generator builder and of the constructor of large power transformers. In other words, it raises the switchgear to the same high level of durability and efficiency.

Development of the Reyrolle Works

Messrs. A. Reyrolle & Company Limited have always specialised in switchgear productions, and since 1905 have had their establishment located on Tyneside. The factory has grown from modest beginnings to the present establishment, which comprises 3½ acres of workshops and administrative offices, on a site 5½ acres in extent. Recent extensions to the works have been necessitated by the growing volume of business, and it is interesting to note that this undertaking is probably the only one in England exclusively devoting its energies to the manufacture of a distinctive design of armour-clad switchgear for E.H.T., H.T. and L.T. circuits.

Design

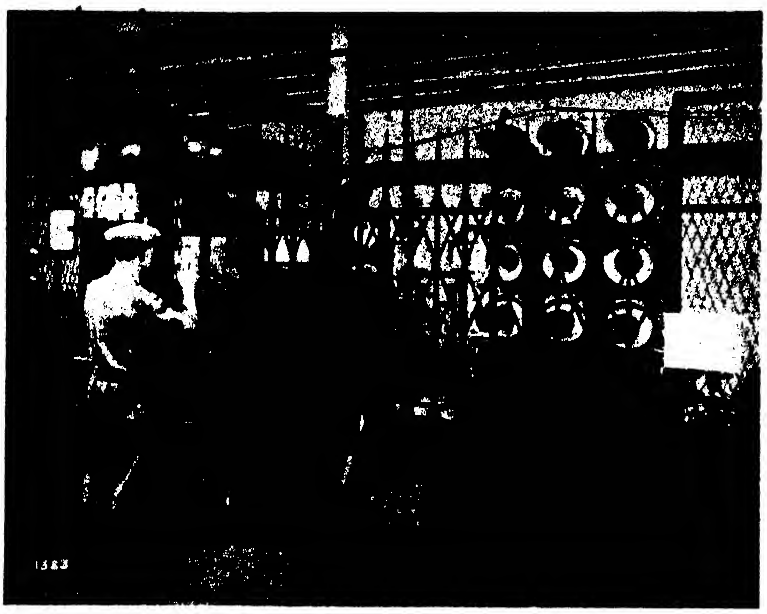
The Reyrolle gear was originally designed on the basis of safety for the operator, reliability of service, absence of fire risk, and economy of space occupied. That this was a justifiable ideal has been proved in the course of twenty years' experience, and the busy character of the works to-day testifies to the wide appreciation of the firm's products. The Reyrolle Company essentially treat the manufacture of their switchgear as an engineering proposition, and are convinced that it is in the best interests that it should be manufactured in well-lighted and spacious shops. This Company claims —and with justice—that it has taken central station control gear into the realm of heavy engineering, its legitimate place in the electrical industry. And the success of their efforts is the reward of courage in producing armour-clad control gear differing markedly from designs regarded as orthodox.

Space Occupied

One of the great advantages of the gear is that by its use considerable economy of space is secured. In many of the older power stations and sub-stations, the brick cubicle type of switchgear occupied a considerable amount of space, but the introduction of Reyrolle armour-clad gear has effected great improvement in this direction. The control gear of this type for a super-power-station can be installed in such a manner as to give ready and safe access to each section and to place the whole of the apparatus within sight. With this type of gear there is also increased reliability, and this has been found to justify a higher capital outlay than would be necessitated in connection with the older designs.

The Shops

Altogether, the Reyrolle works at Hebburn-on-Tyne afford employment to 1,100 persons, these producing an average of 140,000 K.W. of armour-clad switchgear every week. One of the accompanying illustrations shows an erecting shop, while others show the test room cubicle and typical products. The main building, which is at floor level, is 200 feet long and 200 feet wide, and is divided into five bays each 40 feet in width and served by overhead cranes of from 5 to 15 tons lifting capacity. To facilitate movements a standard gauge railway track runs through the centre and



Test Room Cubicle

side sections. At the north-west side of the area occupied by the works there is a two-storey building 240 feet long and 40 feet wide. The upper storey of this building is used as the insulating and transformer department, and also for the manufacture of large quantities of plugs and sockets up to 30 amps. capacity and for other small repetition work. The ground floor is devoted to the fitting and assembly of mining type switchgear.

Building Extensions

In the recent extensions the space between this building and the main shops has been roofed over to make an additional shop 242 feet long and 25 feet wide, to be used as a separate department for the erection of control boards. A further one-storey building 120 feet long and 40 feet wide is utilised as a pattern makers' and joiners' shop, while a few smaller shops—the original works—of about 30,000 square feet in area, are now used partly as a stores and partly for light machine tool work. The offices cover an area of 7,000 square feet, the drawing office alone taking up 5,800 square feet.

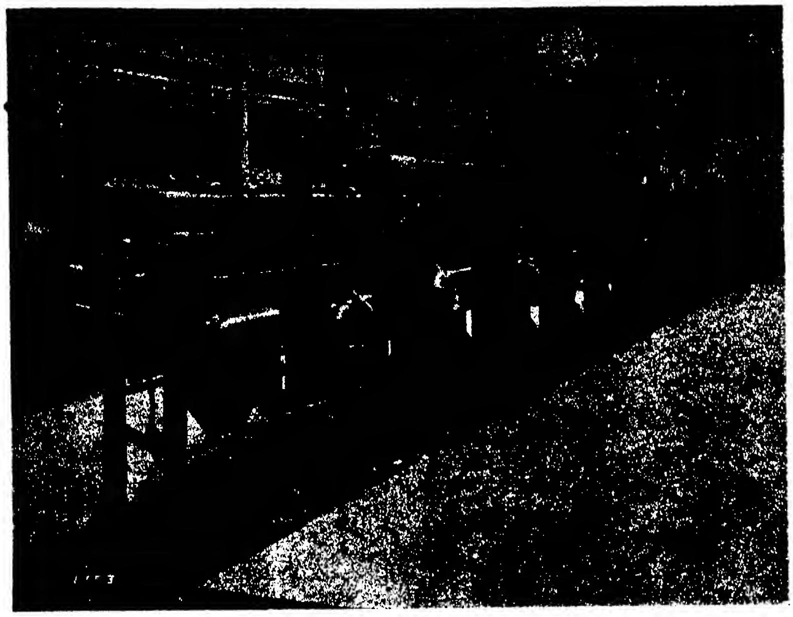
The electric power is supplied to the works by a high tension feeder at 6,600 volts from a 3-phase system of the Newcastle Electric Supply Company. This feeder is brought through Reyrolle outdoor type sealing bells into a 270 K.W. transformer of the outdoor type, situated in the open yard. The total load connected in lighting, power and heating is 2,900 units, part of which power is utilised in an electrically-equipped kitchen from which meals are prepared daily for the staff employed in the offices and works.

Important Contracts

The real success of armour-clad gear obviously depends upon the quality of the insulation of the conductors forming the busbars and interconnections throughout the various panels, and while every possible attention is paid to the individual insulation of these conductors, it is necessary to test them at several times the working pressure. In this respect the works equipment is singularly complete. The testing section occupies a space of 120 feet long by 40 feet wide, and the various portions of gear can here be tested separately under working conditions with complete freedom from risk to the testing operator. Arrangements have also been completed for the installation of a new testing laboratory which will furnish pressures up to 450,000 volts, which equipment, it is suggested, should inspire confidence in the overseas buyer, who is somewhat accustomed to regard such test pressures as the monopoly of American engineers.

Messrs. Reyrolle & Company have been entrusted with a large number of important switchgear contracts for electricity undertakings in all parts of the world. The maximum pressure for which they have applied their "Common Sense" pattern of armour-clad gear is 33,000 volts. They have recently completed a series of orders

33,000 Volt Class RI Switches



Back View 3,300 Volt 3 Phase 50 Cycle Switchboard

applying equally to the colliery and mining pedestal types for low or medium tensions, and to armour-clad draw-out panels for high or extra high tension. Thus, one of the great advantages of this system is its elasticity, and it is that, combined with its many other qualities of reliability, safety and economy, that has made the Reyrolle system famout throughout the world.

Sportsmanship is an element very strongly cultivated in many British circles, and to-day it is even finding a definite expression among engineers. A British society of engineers concerned in automobile design have arranged a series of meetings to be devoted entirely to the free and easy discussion of various motor car parts and accessories.

for Glasgow Corporation, Newcastle Electric Supply Extensions, the Victorian Railways, Cape Town Sub-stations, Shanghai Municipality, Sheffield Corporation Extensions, and others, the total capacity represented being 3,031,000 K.W., and effecting a saving of 598,300 cubic feet in building capacity, and of £64,786. Additionally, the Company has at present in hand large orders including 36 panels for the Birmingham Corporation, 33 panels for the Manchester Corporation Sub-stations, 13 panels for the Leeds Corporation, 13 panels for the Yorkshire Electric Power Company, 24 panels for the South African Railways, and 22 panels for the Charing Cross Conversion and Extension, the total capacity represented being 1,384,000 K.W., effecting a saving of 416,800 cubic feet in building capacity, and £52,120 in building costs.

Advantages in Country Districts

There can be no doubt that the extension of power schemes in many directions, and particularly into country districts, has been hastened by the greatly simplified design of sub-station possible with the use of armour-clad gear. The armouring of the gear, cables and transformers renders the use of outdoor sub-stations absolutely safe. All-weather switchgear is becoming a common feature of power supply systems. This is where the Reyrolle equipment has an advantage. With that system complete boards may be built up and added to from time to time on the unit principle, an arrangement

During recent years there has been a marked growth in the number of large engineering and industrial combinations in Great Britain with a view to enabling the largest contracts to be readily undertaken—and, upon occasions, financed.

Q Department, Showing Erection of R and M Gear

Electric Detector for Recording the Hardening Temperature of Steel

The following article has been compiled from data supplied by the Automatic & Electric Furnaces Ltd., London, and describes the process and principles in using the Wild-Barfield automatic electric furnaces, and records some highly instructive information regarding the non-magnetic condition of steel and temperature. We are also indebted to the above firm for the loan of blocks.*

STEEL is at the base of modern manufacturing industry. From motor cars to sewing needles, from crankshafts to watch pivots, practically every manufactured article is in some way associated with steel, which either enters directly into its composition, or is employed in the multitudinous machines and processes through which it passes to become a finished product.

It is needless, therefore, to say that the use and treatment of his steel is of vital importance to every manufacturer. His appreciation of this fact is shown by the interest he displays in the developments of steel manufacture, and the care with which the grades of steel most suitable to his particular products are selected.

The hardening of the steel is the vital operation. On the unseen grain structure inside the steel depends its useful future. Correct hardening is imperative if the steel is to do its work properly. Scientifically speaking, hardening is a very complex process—like the freezing of water—but, like the freezing of water, it obeys a simple physical law. This law is that if steel be heated and magnetised, *it loses its magnetism when its molecular condition is right for quenching*. Only if the heating is stopped at this point, and the steel quenched at once, can the very fine grain be secured which is essential to the highest ultimate strength, stiffness, hardness, resistance to wear and cutting power. This law applies to all carbon steels, as well as to the majority of alloy steels in commercial use to-day.

A knowledge of the magnetic change is therefore essential if the operator is to know the exact time at which to quench the steel.

This is provided by means of the Wild-Barfield patent magnetic detector, which is based on three well-known physical phenomena :—

(a) When steel is surrounded by a coil of wire through which an electric current is flowing, it becomes magnetised.

(b) If the magnetised steel be heated, it becomes, after a period, non-magnetic.

(c) The non-magnetic point for all carbon and most commercial alloy steels coincides with the point known to metallurgists as the AC_2 point, and is the true, correct and only hardening point.

The detector is operated by means of an outer winding superimposed on the heating coil of the Wild-Barfield electric furnace, this outer winding being connected up to an indicator designed to give a visual signal to the operator of the furnace.

The following description of the theory and practice of steel heating, supplied by Messrs. Automatic & Electric Furnaces Ltd., gives a clear insight into this rather involved subject :—

When an eutectoid steel (a steel containing 0.9 per cent. of carbon) is heated, it undergoes two main transformations. The first transformation takes place at a temperature of about 730 deg. C., and is commonly known as the AC_1 change. In the process heat units are absorbed or become latent, and this is shown by the phenomenon called decalescence, the rate at which the temperature rises becoming suddenly reduced or even negative for a short period. The second transformation, known as the AC_2 change, takes place at a temperature of about 760 deg. C. It is accompanied by a complete loss of magnetic susceptibility, the permeability falling to unity. Metallurgists are not completely agreed as to the true meaning of these changes, but it is generally believed that the first transformation is due to the carbon going into solid solution, and that the second transformation is due to a change taking place in the molecular state of the iron. These transformations do not take place suddenly, but are both spread over a range of temperature, and take time to complete, so that the actual temperature attained during the processes depends upon the rate at which heat is being forced into the steel.

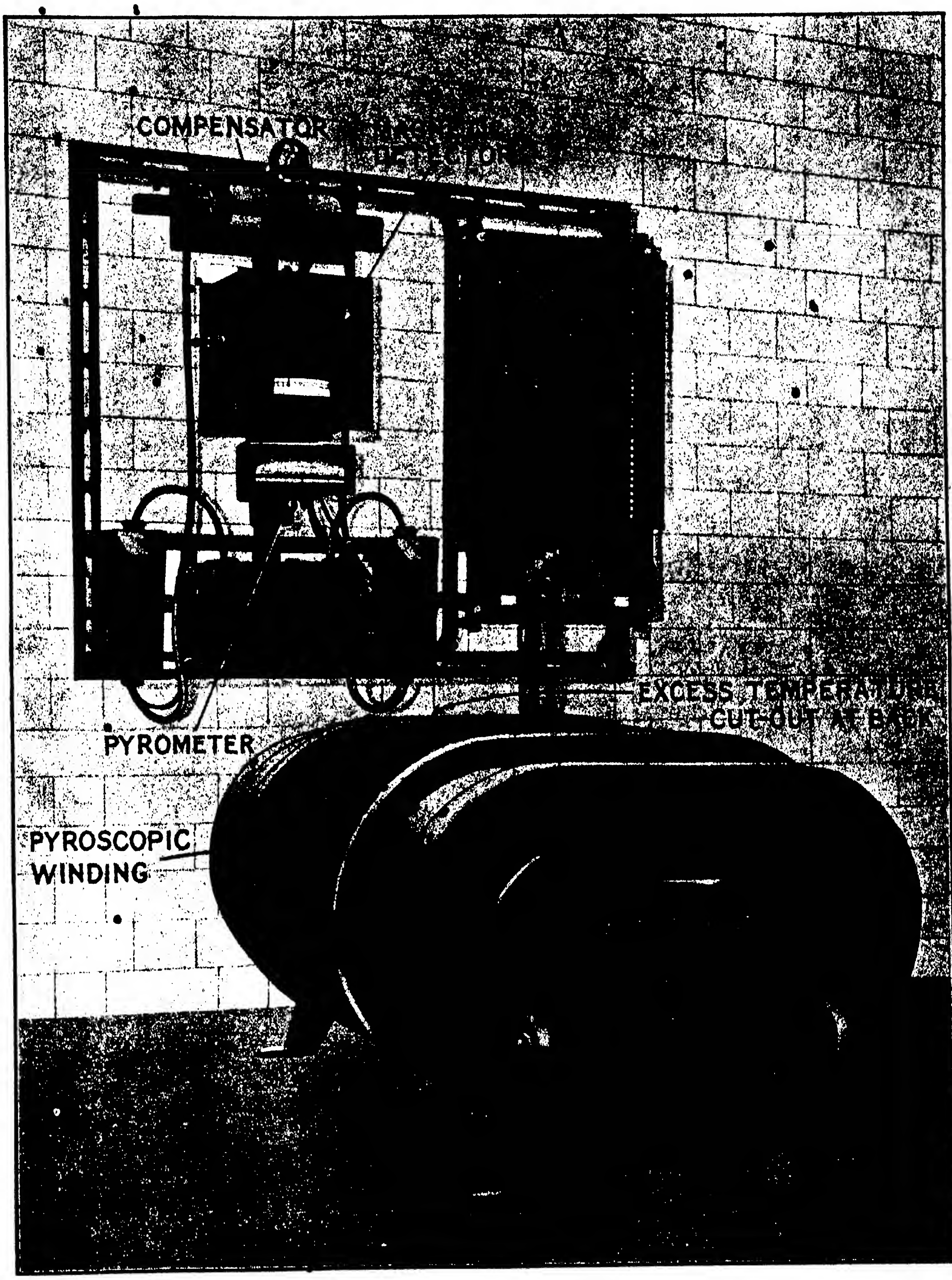
Text Book Metallurgy

The writers of text-books are rather too fond of drawing pretty diagrams in which these two factors are disregarded. If a piece of eutectoid steel is heated to such a degree that the first transformation is just completed and is then quenched, it will be found to be very tough, but only partially hardened. If the steel is heated a little further, till it has just completed the second transformation, and is then quenched, it will be found to be very hard, and will possess the highest ultimate strength that it is possible to obtain by any heat treatment. If the temperature is still further raised, and especially if the steel is allowed to soak at an excessive temperature for any great length of time, it will be found after being quenched to be still just as hard, but mechanically weak and very brittle.

The Uses of Electro-Magnetic Heating

The opening for electro-magnetic heating thus becomes apparent. So far only eutectoid steel has been considered. If the steel contains less than 0.9 per cent. of carbon, the excess of iron exists in the annealed state as free ferrite. Absorption of the ferrite commences as soon as the first transformation commences, and is completed before the second transformation is finished, provided that the carbon content is not lower than 0.4 per cent. When the carbon content is less than 0.4 per cent., further heating is required to complete the absorption of the ferrite. Commercial iron requires heating to as high a temperature as 900 deg. C. as a rule to complete the change. Thus, for steel containing less than about 0.4 per cent. of carbon, there does not appear to be much opening for electro-magnetic heating.

In a steel containing more than 0.9 per cent. of carbon (hyper-eutectoid)



Standard "Flat" Furnace Equipment

the excess of carbon exists in the form of cementite or iron carbide. It is this cementite which gives tools of high carbon steel their excellent cutting properties. Hyper-eutectoid steels should be heated to just beyond the second transformation. If they are heated much beyond this point, the cementite is absorbed and they lose their cutting property, besides becoming very brittle.

The Behaviour of Eutectoid Steel

Fig. 1 shows what occurs when a piece of eutectoid steel is heated. The lower curve shows the inverse heating rate—that is, the number of seconds taken by the steel to rise 1 deg. in temperature. It will be seen that the rate of heating begins to fall off at a temperature of 727 deg. C., becomes very slow at about 740 deg. C., and returns to normal at 755 deg. C. This is the AC_1 transformation. The upper curve shows the magnetic susceptibility of the steel. The scale is quite arbitrary, being merely the number of scale divisions on the ordinary indicator belonging to the furnace. At 745 deg. C. the steel begins to lose its magnetic susceptibility, but not till 790 deg. C. is reached is the change complete. At this point the steel should be removed and quenched. The same specimen of steel was found to complete its change at a temperature of 765 deg. C. when heated very much more slowly. This interdependence between rate of heating and temperature attained gives the electro-magnetic system of working a tremendous advantage over all other methods in use. When the steel has just lost its last trace of magnetism it is just ripe for quenching. If it is removed too soon or too late from the furnace only harm can result.

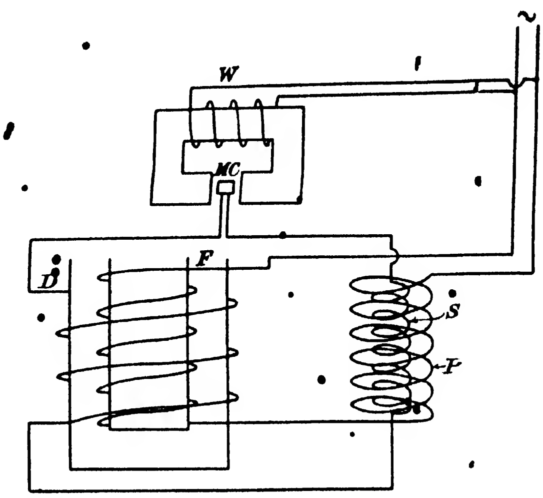


Fig. 2

Some people assert that after the steel has become non-magnetic it requires some further heating or it will not properly harden. This is a complete fallacy. These people have not been provided with means of testing the magnetic state of the steel with sufficient precision.

It will be seen from the curve that the last 10 per cent. of magnetism requires for its removal a range of 20 deg. in temperature and four minutes in time. Most magnetic detectors are too insensitive to detect the last few per cent. of magnetic susceptibility. Fig. 2 shows diagrammatically the Wild-Barfield system of electro-magnetic heating for alternating-current working, where F is the heating winding wound on the furnace liner. D is the detector coil wound outside the furnace casing (F and D in conjunction form a quadrature transformer), and P is the primary and S is the secondary winding of the compensator. This constitutes another quadrature transformer. The compensator is furnished with an iron core which is used to adjust the voltage induced in the secondary coil, so that it balances against the voltage induced in the detector coil. MC is the moving coil of the indicator. It is mounted between the poles of an electro-magnet, the energising coil of which is connected as a shunt across the mains.

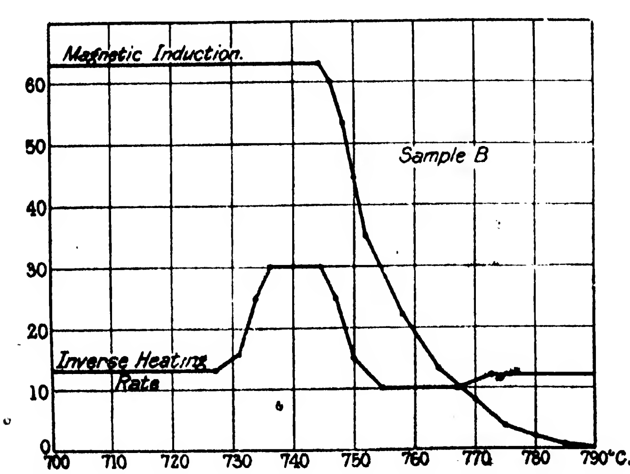


Fig. 1

An Example of Electric Control

To take a concrete example, let us consider the case of a No. 4 radiation furnace. This has a heating chamber 4 in. in diameter and 13 in. deep. First let us neglect the influence of the ohmic resistance of the indicator magnet coil, eddy currents and hysteresis. At 50 periods and with no steel in the furnace, there will be an E.M.F. of 2 volts induced in the detector winding of the furnace. This will be in exact quadrature with the current in the primary of the compensator. These two E.M.F.'s are, therefore, in phase or in direct opposition according to the way in which they are connected. The connections are made and the core of the compensator adjusted so that they neutralise each other exactly, and no current passes through the moving coil of the indicator.

Now let us place in the furnace a piece of steel, 8 in. long and 0.5 in. in diameter. Obviously the mutual inductance between the heating and detector coils is increased. The E.M.F. induced in the detector coil is

now increased to 3 volts. The compensator still only delivers 2 volts, so that 1 volt is available to pass current round the whole secondary circuit. This current, if self-induction can be neglected, will be in quadrature with the main current taken by the furnace, and, therefore, also in quadrature with the supply voltage. The flux passing between the poles of the magnet in the indicating instrument will also be in quadrature with the supply voltage, so that the flux from the magnet and the current in the moving coil will be in phase, and if there is little controlling force the moving coil will turn from its neutral position through an angle of nearly 90 degs.

When the steel has been sufficiently heated to undergo its second transformation, it will become non-magnetic, the voltage induced in the detector winding will fall back to 2 volts, and the original balance will be restored. The operator has simply to watch the indicator, and never need know anything at all about temperature or rate of heating. With the indicator sent out with this size of furnace, a movement of the pointer of 0.5 in. is produced by an out-of-balance E.M.F. of 0.01 volt, so that it is apparent that the indicator is amply sensitive enough for detecting the last disappearance of magnetic susceptibility, provided that the furnace is used on not too small a load of steel.

The Workshop Furnace

In a furnace designed to meet the hard wear of workshop conditions the phasing cannot be carried out so perfectly as under ideal conditions, but nevertheless success has been attained. The workshop furnace is enclosed in a case of sheet aluminium, and is provided with a top and base of cast iron. We thus have to take into account both hysteresis and eddy currents. The compensator core also introduces both eddy current and hysteresis phase displacements. In addition to this the magnet coil of the indicator has ohmic resistance, so that the magnetic flux does not lag behind the supply voltage by as much as 90 deg. Fig. 3 shows the effect of these phase disturbances in the form of a vector diagram. OA represents the phase of the supply voltage and the current through the furnace winding. OB is the flux between the poles of the indicator magnet. OC is the E.M.F. induced in the compensator secondary, and OD is the E.M.F. induced in the detector coil when there is no steel in the furnace. These two E.M.F.'s are not quite equal, and they give rise to a resultant E.M.F., CD, which is, however, in exact quadrature with the magnet flux, so that although there is current flowing through the moving coil, it causes no deflection of the coil, as it is in quadrature with the magnetic field in which it is placed.

When a piece of steel is placed in the furnace the E.M.F. induced in the detector coil is increased from OD to OE, the resultant E.M.F. becomes CE, and this can be resolved into two components EF in quadrature with the flux and FC in phase with the magnetic field, so that a deflection of the moving coil is produced. The introduction of steel into the furnace not only increases the current in the moving coil, but it also materially alters its phase angle. Under certain circumstances it might even reduce the actual current and operate by shifting the phase angle almost entirely.

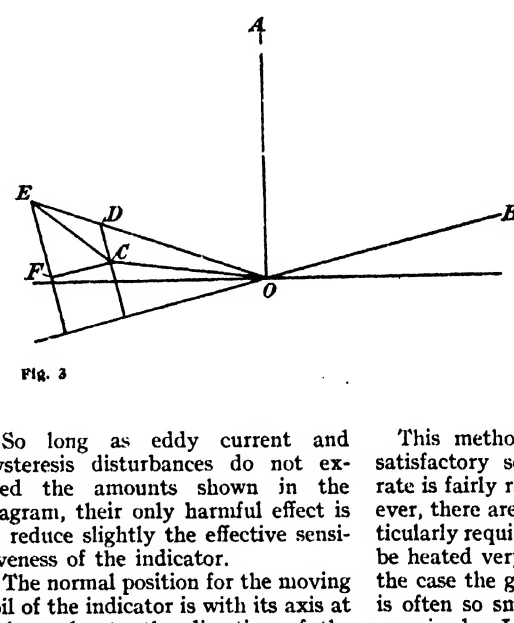


Fig. 3

So long as eddy current and hysteresis disturbances do not exceed the amounts shown in the diagram, their only harmful effect is to reduce slightly the effective sensitiveness of the indicator.

The normal position for the moving coil of the indicator is with its axis at right-angles to the direction of the field in which it moves. As soon as it is displaced from this position an E.M.F. is induced in it by the field. This gives rise to a current flowing right round the whole secondary circuit. This current reacts with the magnetic field to form a very strong controlling force, so that it is quite possible to work an indicator without any other control. If a resistance equal to about the whole of the secondary circuit is added to the moving coil, the control is weakened and the sensitiveness of the instrument is actually increased considerably. A damping force is produced when the moving coil is started swinging just as in a moving coil galvanometer with closed circuit, so the indicator can be constructed to have a quick period of swing and to be practically aperiodic.

For continuous-current circuits the alternating indicator is replaced by a low resistance galvanometer. The compensator is still retained.

If now a piece of steel is introduced into the furnace a ballistic throw will be momentarily obtained. As soon as the steel begins to lose its magnetism, and lasting until all the magnetism has gone, a continuous current will be obtained in the secondary circuit, and the galvanometer spot will travel slowly up the scale and back again, the position at any moment depending upon the rate at which the magnetism in the steel is decaying. As soon as all movement of the galvanometer spot ceases, the steel should be removed from the furnace and quenched. When the compensator is correctly adjusted the ordinary fluctuations of the supply voltage do not produce any kicks on the galvanometer spot. This is because every fluctuation, whilst producing an impulse in the detector coil, also produces an equal impulse in the opposite direction in the compensator.

This method of working is quite satisfactory so long as the heating rate is fairly rapid. Sometimes, however, there are reasons when it is particularly required that the steel should be heated very slowly. When this is the case the galvanometer movement is often so small as not to be easily perceived. In such cases the procedure is either to draw the steel to the mouth of the furnace at intervals, noting whether this produces any movement of the spot, or else to switch off the furnace current for a moment at intervals, for if the compensator has been adjusted to balance the furnace exactly with no steel in the furnace, it will not so balance exactly after steel has been introduced until the steel has attained the non-magnetic condition.

Low Temperature Carbonisation (xii)

(THE "LAMPLOUGH" PROCESS)

By DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Mech.E., Mem. Am. Soc. M.E., A.I.Mech.E., etc.

THE "Lamplough" process is designed chiefly for the maximum oil production by the low temperature carbonisation of coal, and consists essentially in heating the roughly-pulverised coal by means of superheated steam at a definite and controlled temperature, so that this heating steam passes through the charge inside the retorts (internal heating), the pulverised coal travelling continuously in the reverse direction by means of mechanical agitators or conveyors, whilst the retorts are at the same time also heated to a very limited extent by external combustion chambers or furnaces. The chief object of all low temperature processes is, of course, to convert as much as possible of the volatile matter of the coal into liquid products of the paraffinoid series with as low boiling point as possible, especially for use as motor spirit, and to avoid in the carbonisation the partial decomposition of these valuable products with the formation of benzenoid compounds, that is aromatic hydrocarbons such as benzene, toluene, naphthalene, anthracenes, etc., acids such as carbolic acid, together with a large proportion of complex organic compounds in the form of pitch and tar. Mr. Lamplough is of the opinion that one of the difficulties of low temperature carbonisation in this respect is that there is a certain very short transition stage within a very limited range of temperature in which the paraffinoid compounds formed almost exclusively are suddenly decomposed, and large amounts of benzenoid substances result. That is to say, the temperature control of the process must be very accurate, and under perfect control, if the large proportion of paraffinoid compounds formed are to be preserved, and most low temperature processes are defective because this vital point is not realised, and the methods of control of the temperature are much too crude.

Thus a large amount of secondary decomposition is stated to be caused by the gaseous and volatile compounds from low temperature carbonisation processes in general coming into momentary contact with the sides of the hot retort and various other parts of the equipment which are at a higher temperature than the decomposition zone. Mr. Lamplough also urges the absolute necessity of a complete control of the temperature, because he is of the opinion that the general process of carbonising the coal is endothermic, that is, heat has to be absorbed from outside sources until a certain point, the paraffinoid decomposition limit, is reached, when it suddenly becomes exothermic, that is to say, a reaction takes place, and heat is given out so that the temperature naturally rises rapidly and is very difficult to control. The range of this critical temperature of carbonisation is 705-820 deg. F. (375-440 deg. C.), and 820 deg. F. (440 deg. C.) is the absolute maximum temperature. Mr. Lamplough states that over 1,110 deg. F. (600 deg. C.) the process becomes what is generally known as high temperature, and a large yield of complicated substances —chiefly in the form of pitch—results, which amount from anything up to 35-40 per cent. of the total oils produced, while the motor spirit at this temperature is nearly all benzene, that is, benzenoid, and not paraffinoid.

In order to avoid exceeding the given range of temperature, and even momentary contact with the hot retorts or other portions of the plant above the limit, the carbonisation in the "Lamplough" process is practically effected by internal heating with superheated steam at a definite temperature, combined with, when required, a small proportion of the hot gases. Any rise in temperature due to exothermic reaction is kept easily under control by adding steam as required at a lower temperature, whilst the temperature is even and uniform at all points because of the internal heating. The amount of external heating used is very small, and there is little danger of reaction in this direction owing to the circulating steam equalising the temperature throughout the apparatus.

Combined with this the "Lamplough" process includes roughly pulverising the coal, keeping it in constant motion whilst carbonising, so as to ensure uniformity and the briquetting of the residual low temperature fuel whilst hot and plastic. Further, the carbonisation is gradual in successive zones of temperature, so that the products of one zone are driven off before the next is entered upon, the first zones being purely exothermic in their reaction, and the last stages endothermic. The nett result is claimed to be that the liquid products are entirely paraffinoid, and contain no trace at all of benzenoid compounds, whilst the whole of the organic sulphur present is practically all left as free sulphur, and the particularly obnoxious benzenoid sulphur compounds are entirely absent, so that refuse coals containing as high as 8 per cent. sulphur can be treated.

The "Lamplough" plant, like most others, has undergone a gradual evolution. In the first patent the heating was external by means of producer gas, but this type of retort (illustrated in Figs. 1, 2 and 3) is interesting as showing the methods used for obtaining the regular heating of the coal and the internal conveyors used.

Fig. 1 is a longitudinal section of the retorts, constructed of horizontal steel tubes, and Fig. 2 is an end view, showing a section of the discharge receptacle, Fig. 3 showing a portion of the apparatus on a larger scale. The coal, in a roughly pulverised condition, is brought to the coal measuring hopper (A) through a trough (B) by means of a worm conveyor (C) working in the trough, which has a suitable orifice above the measuring

hopper (A). The measured charge of coal is discharged to the retorts through the vertical outlet (A2), the hopper (A) containing in it two concentric shafts (D, D1), not shown in the illustrations, which, by suitable operating gear, are rotated, and projecting blocks (E, E1) carry forward a definite amount of coal and discharge it through (A2). A steam pipe is also fitted to the hopper casing so that low pressure steam passing in excludes air from the hopper casing, and then travels on through the retort, assisting to drive off the rich hydrocarbons as fast as they are formed, and reducing "cracking," to a minimum. It will be noted in this first patent that the heat of the steam is not entirely used for carbonising.

The charge of coal on discharging through (A2) then falls into an extension (M1) (Fig. 3) of the uppermost retort (M). The horizontal tubular retorts (M) are arranged in a series one above the other, as in Fig. 1, within a furnace setting (N), and each of these retorts contains inside a worm conveyor (M2), as shown in detail in Fig. 3. These worm conveyors are each operated by the toothed gearing (O), the bearings being water-cooled at (P). The roughly pulverised coal, therefore, by means of these slow-moving internal worm conveyors, travels along inside the top retort (M) from the coal feed hopper (A), and then falls out of the end of the retort down into the next retort (M3) as shown in Fig. 3, and by the alternate arrangement of the worm conveyor then travels along inside this retort the reverse direction, falling down at the end into the next retort underneath, and so on through the whole battery of retorts until finally the fuel emerges at the bottom and falls into the receptacle (Q), Fig. 1, into which also passes all the gases and vapours evolved. These latter pass out through the outlet (R), Fig. 2, to the ordinary by-product plant, and are treated in the usual way. The residual low temperature fuel, which still contains 10-12 per cent. of volatile and tarry matter, is conveyed continuously out of the receptacle (Q) by the screw conveyor (S), Fig. 2, and passes out of (S) to a suitable press for briquetting. Generally speaking, the battery of retorts is constructed of such a size that the total of 144 feet of tubing is exposed to the furnace.

The temperature within the setting is maintained at about 750-1,020 deg. F. (400-500 deg. C.) by means of producer or other suitable gas in the ordinary way, according to the quality of the coal, and the travel is roughly at the rate of 0.83 feet per minute, so that the total time of carbonisation is 120 minutes.

In a later patent (1916), Mr. Lamplough uses low pressure superheated steam as the heating medium for carbonisation in direct contact with the coal in special vertical retorts. Each of these retorts, which are erected in groups in the form of a battery, is provided with an inlet for the superheated steam, a principal gas delivery duct and a by-pass delivery duct, the latter arranged in case of necessity that some of the gas when evolved at a fairly high temperature can be diverted to the steam inlet portion of the retort, so that the hot gases will assist the steam in carbonising the coal. The details of the retorts are seen in the illustrations, Fig. 4 being a front elevation of a battery of retorts, and Fig. 5 a section. The apparatus consists essentially of a battery of vertical retorts (A) fitted at the bottom with two parallel mains (B) and (C), and at the top with two other corresponding and parallel mains (D) and (E). The bottom main (B) is supplied with superheated steam, and is known as the steam main, whilst (C) is the by-pass main connected by a downtake main (F) to the upper main (E) known as the by-pass delivery. The other upper main (D) is the gas delivery main. The mains (B) and (C) discharge into a series of inlet ducts (G), one for each retort, communication between these mains and the ducts (G) being controlled by two opposed mushroom valves (H, H1), not shown in the drawing, and controlled as required by a control lever passing through a stuffing box above the duct (G).

In the same way the upper mains (D) and (E) are connected to outlet ducts (G1) through valves (J1, J2), and controlled by valves operated by levers. To the top of each vertical retort is fitted a coal hopper (K) with a suitable discharge mouth containing a perforated grate to support the coal, this grate being pivoted and operated by a lever so that any required amount of coal can be dis-

Fig. 1.

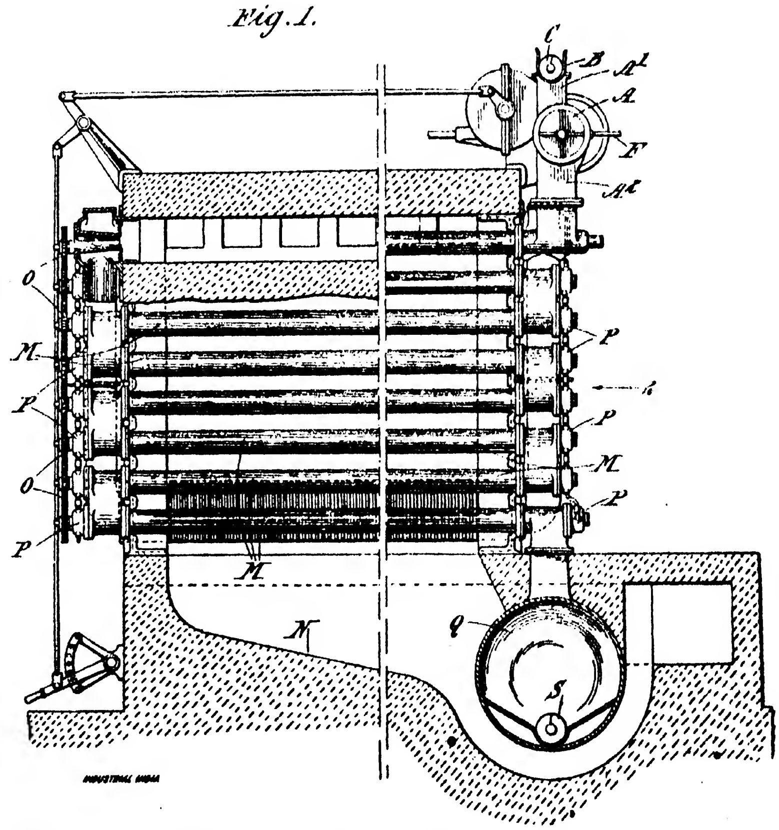


Fig. 1

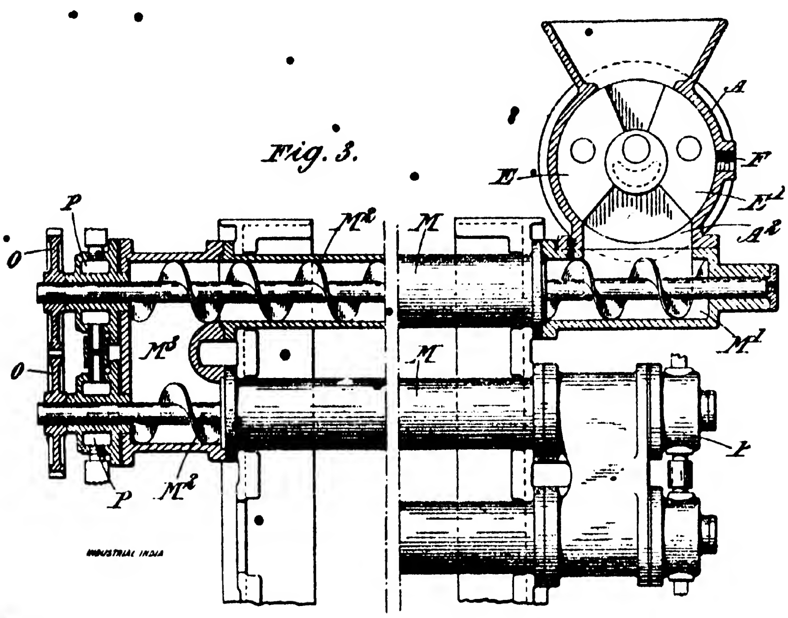


Fig. 3

charged into the retort below. The heating steam is superheated in the special superheater (M) shown in Fig. 5, and exhaust steam can conveniently be used for this purpose along with some low pressure live steam admitted at (O1). The vertical retorts are charged with coal from the hopper, and the superheated steam is admitted at the bottom at any required temperature from 390-1,110 deg. F. (200-600 deg. C.), so as to extract the ammonia after distilling off the oil.

In normal working the superheated steam is admitted from the main (B) through the valve (H), Fig. 5, into the bottom of each retort, and passes up through the coal in the retort, carbonising it at the given temperature, the gaseous and volatile products passing off through (G1) under control of the valve (J) from each retort into the gas main (D), with the valves (H1) and (J1) closed. This is only the case, however, when each retort is evenly packed with coal, and the same amount of steam is passing, which is rarely the case. When the reaction in one retort lags behind the others, one or other of the valves (J1) is opened, and the corresponding valve (J) closed, which diverts into the by-pass delivery main (E) some of the hot gas which would otherwise have been delivered into the main (D), and in this way, by manipulating the valves and the delivery of hot gas, the same amount of carbonisation is obtained in each retort of the battery.

In a still later patent (1918), Mr. Lamplough has then combined the internal screw conveying gear retorts with the principle of both internal heating by means of superheated steam and a slight external heating by means of producer or other gas at the same time. The apparatus is illustrated in Fig. 6, which is a side elevation in part vertical section, and Fig. 7, an end view of the upper portion of one of the retorts of a battery. As seen in Fig. 7, these retorts are oval in cross section, and are mounted side by side in a furnace chamber (B), sloping upwards from the bottom to the top of the chamber at an angle of 30 deg. to the horizontal. In each retort is a stirrer or agitator (A1) with lateral arms placed in the curved bottom of the retort, driven by an outside shaft (A2), so as to prevent the coal from caking. Coal is supplied from the hopper (C) by means of a worm conveyor (C1) through a hermetically sealed rotary coal discharge valve (C2), and this worm conveyor (C1) discharges the coal into a second worm conveyor (D) at right angles, which traverses the top of all the retorts, and is in communication with the upper end of each retort, so that all the retorts of a battery are kept charged from the one hopper (C). At the bottom of the retorts is a corresponding worm conveyor (E) which discharges all the residual low temperature fuel from the battery of retorts. Above the retorts is a cylindrical expansion chamber (F), and each retort is in communication with this chamber through the conduit (F1), whilst the pipe (G) is connected to a steam generator (G1). This is of the tubular type, the upper ends of the tube being in communication with the pipe (G) and the lower ends with the delivery pipe (G2), whilst from another point lower down in the expansion chamber (F) a second pipe (H) is attached, which communicates with a tubular feed heater (H1).

In working the apparatus, the partially pulverised coal is fed continuously into the retorts by the conveyors (C1) and (D), and the residual low temperature fuel discharged by the conveyor (E). The hot gaseous and volatile products given off by the coal as it is carbonised during the descent through the retorts passes into the expansion chamber (F), and thence through the pipe (G), and partly through (H). At starting, the steam generator (G1) and the feedwater heater (H1) are both full of water, and the hot gases from the pipes (G) and (H) heat the water until steam is generated in (G1), and the water in (H1) is heated very hot. The steam generated then passes out through the pipes (J) and (J1) under the retorts, where it is superheated

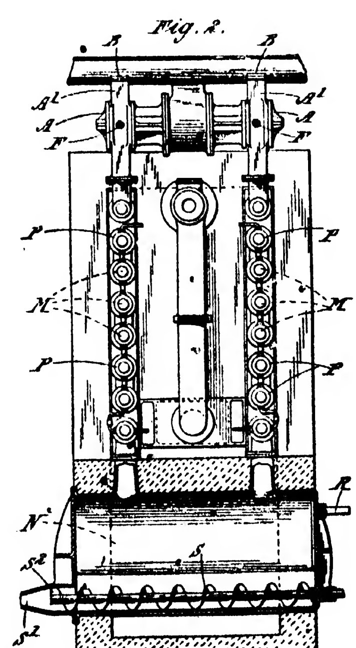


Fig. 2

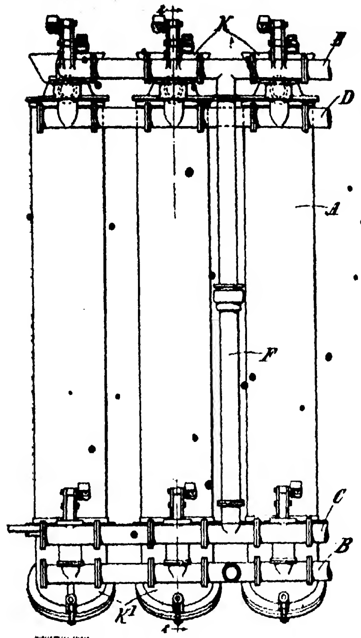


Fig. 4

by a furnace, as shown in Fig. 6, and from here into the bottom of each retort by the connection (J2), as shown. As the amount of steam generated in (G1) increases, the pressure drives some of the water out into the heater (H1), through the short connecting pipe (H3), which, in turn, drives water out of (H1) up the pipe (H3) into the overhead store tank (H4), which thus alters the head and controls automatically the steam supply. The gaseous and volatile products driven off by the carbonisation, after passing through (G1) and (H1), are then treated in a by-product plant as usual. The plant can be arranged with a number of expansion chambers instead of the one (F), so that the heavy fractions automatically separate from the water and lighter fractions.

A modification of this process, as contained in a final patent (1918), is to preheat the coal in a roughly pulverised condition until gas commences to come off, and then passing superheated steam at a predetermined and controlled temperature through the mass. In this variation the superheater is of chequered brickwork on the usual regenerator principle, heated by the gases of combustion from the furnace, as before, the internal steam heating being combined with external furnace heating, and steam then passed through for a short period, using two alternate regenerators as usual. Also, the retort is of the vertical pattern, with a rotary discharge grate at the bottom, on the lines of the ordinary high temperature gas retort. Coal is fed in at the top continuously or intermittently by a gas-sealed rotary coal discharge valve, and part of the furnace gases—consisting largely of CO_2,—together with steam, are passed up inside the retort, which at the same time is heated by outside combustion chambers, but the steam is not admitted until the carbonisation has commenced. As already stated, by any of these processes the gaseous and volatile products pass to a by-product plant, that is, through a system of cooling and dephlegmating towers, and the various liquid fractions separated. The residual gas is then passed through a sulphuric acid tower for absorption of the ammonia with the formation of ammonium sulphate, and then scrubbed for a further supply of motor spirit, and the residual gas is available for light and power purposes, or for heating the retorts as usual.

The efficiency of the process is stated to be high because of the direct internal heating, so that only about 1,200,000 B.Th.U. (5 per cent. of the heat in the coal) is required for carbonisation, whereas most externally fired methods require 2,500,000 B.Th.U. (10.5 per cent.), because of the loss of heat when passing through the retort walls. Against this, however, there is the cost of briquetting.

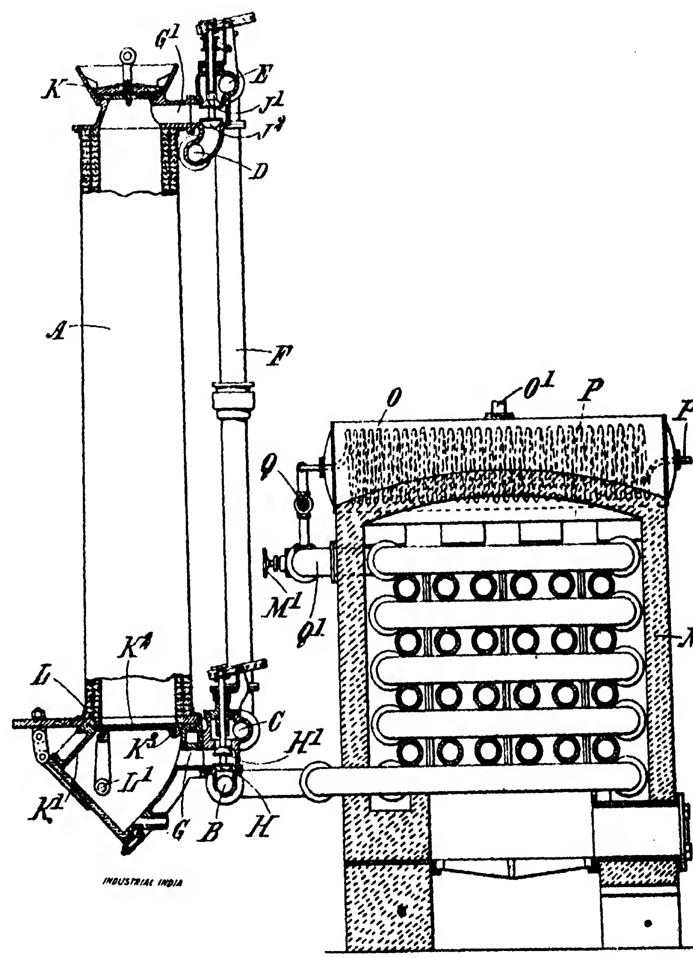


Fig. 5

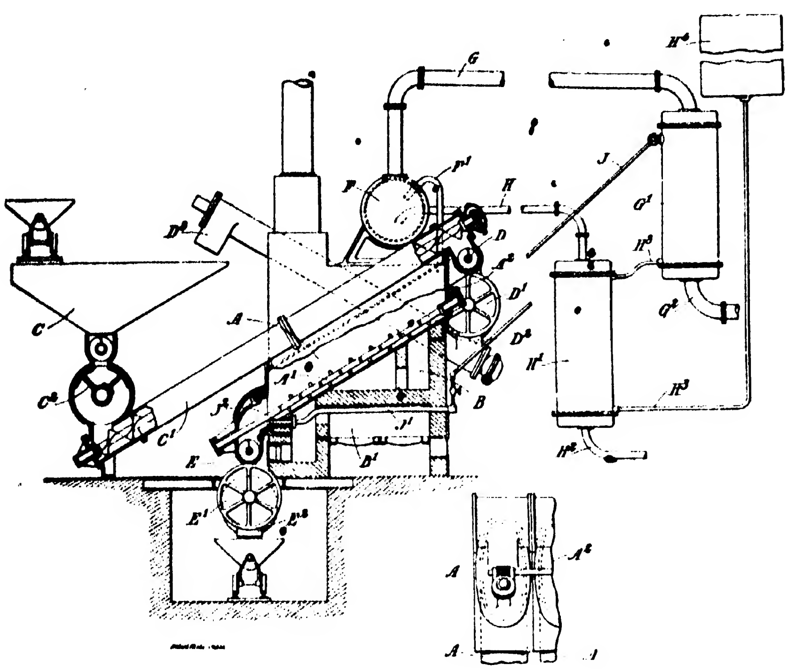


Fig 6

Fig.

The cost of the plant is also claimed to be relatively small, whilst depreciation is less than 6d. per ton, and the cost of labour very low. A large scale plant would be largely automatic in action because of the extensive use made of mechanical conveyors right up to the briquetting stage, and it is claimed that the total labour costs are less than 2/6 per ton. It is maintained, for example, that one man would be able to look after twenty retorts [illegible] 100 tons of coal per [illegible] 75 tons of [illegible] of oil per 24 hours, particularly as the temperature control is largely automatic, depending on the water level in an overhead tank, as already explained. Also, a great variety of carbonaceous material can be handled in the same retort, coal of all kinds, including pit refuse, shales and torbanites, cannel coals and lignites, and there is no need for the blending of coals.

Finally, as regards the yields obtained, 1 ton of average coal, 25-30 per cent. volatile matter, is stated to give the following :—

Gas	ft.	2,000
Motor spirit	galls.	4
Oil	,,	18-20
Sulphate of ammonia ...	lb.	15-25
Residual smokeless fuel	cwt.	15

The yield of gas is very small in the "Lamplough" process, and the 5,000-6,000 cubic feet of rich gas characteristic of many so-called "low temperature" processes is only obtained because of excessive cracking due to too high a temperature at some stage of the carbonisation.

The 20 gallons of oil obtained by the "Lamplough" method is stated to be of very high quality, because of the entire absence of secondary decomposition, and any rise in tempera- [illegible] Th[illegible] [illegible] yields :—

[illegible] motor sprit.
2 gallons burning oil.
2 gallons middle oil.
5 gallons lubricating oil.
3 gallons heavy oil.
4 gallons pitch (20 per cent.). This includes loss, gas and fuel oil.

There is no cresylic acid, which is really a high temperature product like carbolic acid, and Mr. Lamplough maintains that the so-called low temperature processes working at 1,000 deg. F. (540 deg. C.) give 2¼ gallons benzole, 3-4 gallons cresylic acid, 1 gallon light lubricating oil, 3 gallons heavy lubricating oil, and 34 per cent. pitch.

The yield of motor spirit by the "Lamplough" method is very high, being 3-5 gallons per ton of coal, but averaging 4 gallons. It is stated, also, to be of excellent quality, as proved by exhaustive tests carried out by a well-known motor car firm in Coventry.

The yield of lubricating oil is also very high, because of the absence of benzenoid compounds containing oxygen and sulphur. The 5 gallon yield is further fractionated to :—

(1) Sewing machine and light machine oil.
(2) Medium quality lubricating oil.
(3) Heavy lubricating and cylinder oil, the residue from which is gear grease and axle grease, together with some pitch used for briquetting.

The heavy oil can be used as a fuel oil, mixed, if necessary, with any of the other fractions, and the pitch is utilised for the briquettes. The residual smokeless fuel, containing about 10 per cent. volatile matter, besides being available for briquettes, as already stated, can also be used direct in its semi-coked condition for steam generation.

The "Lamplough" carbonisation process can also be combined with another patent of Mr. Lamplough's for cracking heavier oils to motor spirits, known as the "Synthol" process, which it is claimed converts 40-70 per cent. of various middle fractions of petroleum and similar products (such as American gas oil, Russian kerosene, Trinidad middle oils, and low temperature middle fractions) into motor spirit.

BRITISH ROLLING STOCK FOR THE CONTINENT

One of the most conspicuous illustrations of the great repute of British railway stock is supplied by the sleeping cars recently supplied from England for a Continental service. These cars embody many noteworthy advances, chief among which is the extensive use of steel castings in the construction of the underframes. The body framework is of steel throughout, being built up of pressed steel pillars and sheets 1/8th in. thick, of a special quality of steel. All the interior woodwork, which is of polished mahogany, is made in sections which are inter-changeable. Forty cars of this type have been ordered for the Riviera Service across France, and they are noteworthy for their extraordinarily smooth running, even over indifferent railway tracks.

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE :: :: :: :: DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS :: :: :: ::

Wood Fuel Suction Gas Power Plant

The following article and illustrations are reproduced by the courtesy of Messrs. Crossley Bros. Ltd., the article being a reprint from "The Engineer," London.

A LARGE gas-driven electric power plant at the Lonely Mine, Southern Rhodesia, is the largest wood refuse gas plant in South Africa. It was installed recently to replace existing steam plant, the boilers for which used at the rate of some 3,000 cords of wood as fuel per month for steam raising purposes. Owing to the isolated position of Lonely (43 miles from Bulawayo, the nearest railway connection), the use of coal was out of the question on account of the heavy cost of haulage. Wood from the local bush therefore had to be used, but the enormous consumption of it during the past 11 years of life of the steam plant had caused the clearing of the bush to a radius of 11 miles, and had the consumption continued at that rate for three years more the economic limit would have been reached. The cost of wood fuel had indeed become one of the most serious factors of the mining costs, so that some radical change became absolutely necessary.

The question consequently received very close and careful attention by Mr. C. B. Kingston, general manager and consulting engineer, and Mr. J. N. Bulkley, consulting mechanical engineer to the Lonely Reef Gold Mining Company Limited, by whose courtesy we are enabled to give particulars, together with details of tests, and to reproduce some photographs of the new installation.

The decision was taken to adopt electrical driving wherever possible, using individual motors and alternating current supplied from gas-driven alternator sets working in parallel and operated by producer gas generated from wood fuel.

The gas producing plant is of special design, comprising Crossley wood fuel suction gas plants in four units, each at 350 horse-power, giving a total capacity of 1,400 horse-power. But as each gas plant unit is able to take overload up to 450 horse-power, any three units can meet the total power requirements, leaving one unit as stand by. These gas plants serve four Premier multi-cylinder horizontal gas engines. Three of these engines are of the four-cylinder type, direct coupled to alternating current generators, whilst the fourth, which has three cylinders, drives a large air compressor direct through a flexible coupling.

As the result of installing this gas power plant the fuel consumption has been reduced to some 600 cards per month, or one-fifth of the previous fuel consumption upon the steam plant. What this means in actual effect upon the mining costs is shown from the consulting engineer's quarterly report, which states:—"The total cost of power in December was £1,645, as compared with the average cost of £4,557 when the steam plant was in use.* The saving effected by the gas plant is considerably in excess of the estimated saving, and is equivalent to a reduction in the working costs of over 10s. per ton milled." A further point of very considerable importance is the fact that, when using wood fuel in the steam boilers, the soft green Marula trees could not be burned, and were therefore left standing in the area already cleared of all other wood. It is now found that these trees can be satisfactorily used as fuel in the Crossley gas plant, and, in fact, give excellent results.

*Later information from the consulting engineer at the mine for six months' working now shows the average monthly saving to be £3,015—due to the new gas power plant.

Gas Plant

Before dealing with the tests it may be well to give the following additional details:—The complete gas producing plant was supplied by Crossley Brothers Limited, of Openshaw, Manchester. It is illustrated in Fig. 3, which is reproduced from a photograph taken on the site, and shows the large overhead platform built around the gas generators, from which the wood fuel is fed into the hoppers. The wood used is about 10 in. in diameter, and is cut into pieces about 2 ft. in length. The feeding-hopper mounted at the top of each generator is of the air-lock type. The hot gases as they leave the generator first pass into a wet scrubber, where they are washed and cooled. Within this wet scrubber much of the tar coming over with the gas is condensed and carried away by the cooling water into settling tanks, where it collects and is afterwards removed. The effluent water ultimately flows away in a comparatively clean state.

Fig. 4, from another photograph of the gas plant, shows an end view. Here, in the foreground, can be noted the arrangement of the various vessels comprising one complete gas plant unit. The wet scrubber referred to is the tallest vessel in the centre. The gas enters it at the base and passes upwards, meeting in its course a cascade of cooling water which falls from the top. The cooled gas leaves the scrubber at the top, and descends through the vertical piping into a centrifugal tar extractor situated on the floor level. This extractor runs in ball bearings, and is direct driven by an electric motor. Here further traces of tar and tarry deposits are effectively removed from the gas, which then enters the dry scrubber,

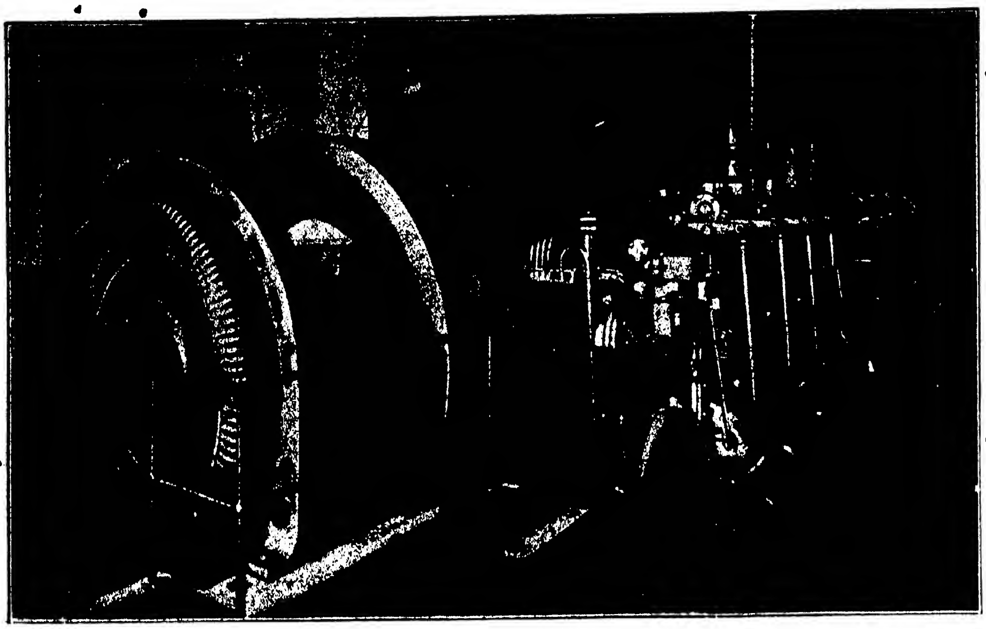


FIG. 5

where any particles of moisture are got rid of. This scrubber is shown to the left-hand side of Fig. 4. All of the four dry scrubbers—one to each gas plant unit—are coupled together in a manner that will be referred to later.

Gas Engine Sets

The four gas engine sets supplied by the Premier Gas Engine Company Limited, Sandiacre, near Nottingham (associated with Crossley Brothers Limited), are all of the firm's horizontal multi-cylinder type, all with cylinders of 17½ in. bore, with a stroke of 26 in. As already mentioned, three of the engines drive three-phase alternators, each of 250 k.V.A. capacity at .8 p.f., with 525 volts at 187.5 revolutions per minute. These alternators were supplied by the S.A. General Electric Company Limited. The gas engines are designed for 300* brake horse-power normal working load, and will carry a 25 per cent. overload. The fourth engine develops 225* brake horse-power at 190 revolutions per minute, and is connected through a flexible coupling with an Ingersoll-Rand air compressor having a capacity of 1,500 cubic feet per minute. Fig. 1 is reproduced from a photograph of the power-station, and shows the arrangements of engines viewed at the crank shaft end. Fig. 5 is another view of the power-station, and shows how one of the alternators is mounted on the crankshaft alongside the engine flywheel.

Fig. 2 shows a general arrangement plan and elevation of the complete equipment within the gas plant and engine houses. The gas piping arrangement already referred to is clearly shown, as is also the exhaust piping, a part of which is water jacketed to supply a service of hot water for baths and washing purposes. Air storage receivers are provided for starting up the gas engines. They are charged up from motor-driven compressors.

The question of operating the alternator sets in parallel with each other was given very special consideration by the manufacturers. So far as the gas engines are concerned they are easily capable of fulfilling the required conditions, being of the four-crank

*At altitude of 4,200 feet and at reduced speeds to suit alternators.

FIG. 1

Fig. 3

continuous test was made first, working under normal conditions, but using only two producers, these being sufficient to serve the three 200-kilowatt gas engine alternator sets. The fourth engine, which is used for driving the air compressor, was not tested, one of the gas producers being coupled up to serve this engine exclusively during the test. The fourth producer was shut down entirely throughout the tests.

type and designed to give a degree of cyclic irregularity not exceeding 1/500. To ensure this degree of steadiness under all conditions of working, a uniform quality of gas must be supplied to the engines. For this reason a special arrangement of equaliser pipes was introduced between the dry scrubbers of the gas-producing plant, and arranged in the following manner:—The scrubbers are first coupled together in pairs by means of overhead pipes, and these pipes in turn are coupled together and lead into one common main delivery pipe. The arrangement can be noted in Fig. 4, and is interesting as showing the means adopted for ensuring thorough mixing of the gases together after they leave the dry scrubber. A further point is that the suction from each of the gas engines when in operation is more evenly distributed, with the result that each gas generator responds to its fair share of the load and generates gas in proportion.

Tests

Tests were carried out upon the installation by Prof. Buchanan, B.Sc., of Johannesburg, and the following particulars are extracted from his report dated February 21st, 1922:—

The main object of the tests was to determine the quantity of dry wood fuel consumed within the gas plants in generating one Board of Trade unit of electricity. A twenty-four hours'

Care was taken to note that the amount of fuel within the producers was the same at the beginning and finish of the test. The wood fuel used was of a normal mixture of Mapani, Knobby-Thorn, Marula, and other soft woods.

The makers' guarantees given with dry wood fuel were as follows:—

	Lb. per b.h.p. hour.
At full load...	2.0
At three-quarter load ...	2.23
At half load	2.76
At quarter load	3.9

Fig. 4

DETAILS OF TESTS.

Date of test ...	February 2nd and 3rd, 1922.
Duration of test	24 hours 13 min.
Total units generated measured at the switchboard	11,530 units
Average load from three sets	477 kilowatts
Load factor (say 160 kilowatts per set) ...	80 per cent.
Corresponding power developed by each engine (89.5 per cent. alternator efficiency)	239 brake horse-power
Total wood fuel used during test	41,208 lb.
Fuel used per hour	1,703 lb.
	Per B.H.P. Per K.W.
Fuel consumption rate at 80 per cent. load	2.39 lb. 3.575 lb.
Average moisture content in fuel	13.5 per cent.
	Per B.H.P. Per K.W.
Equivalent dry fuel consumption rate at 80 per cent. load	2.07 lb. 3.09 lb.

A curve made from the makers' guarantees shows that at 80 per cent. load the corresponding fuel consumption would be 2.15 lb. of dry fuel (see Fig. 6). As may be seen, therefore, the actual test result is 4 per cent. below the guarantee.

The watt-hour meter was calibrated before leaving Johannesburg, and the station instrument and feeder watt-meters checked against it. The net difference in the readings was within 2 per cent.

After the main test, and whilst the three sets were operating in parallel with a load of about 500 kilowatts, first one, then a second sparking plug was disconnected from one engine (thus cutting out two cylinders) without causing any appreciable effect in the parallel operation of the machine. No doubt the synchronising current was increased, but owing to the load fluctuations the difference could not be observed.

After continuous running on ordinary load, one of the alternators was taken off load, leaving two machines operating at 400 to 460 kilowatts for over two hours. This represents more than 10 per cent. overload. Temperature readings taken at the field and stator windings immediately the machine was shut down showed that the temperature increase was within the usual guarantee of 50 deg. C.

The power factor indicator was provided with resistance coils for 110 volts, which were unsuitable for the voltage of 280 to neutral, so three transformers belonging to the mine were used to reduce this pressure; the readings, however, seemed not quite consistent, and were not noted during the test. Instantaneous reading of volts, amperes and kilowatts were, however, taken every half hour, and although it was difficult to get a steady value, owing mainly to the varying synchronising current, the average over any particular period must be fairly correct.

From 11.30 to 2 p.m. the average total load was 580 kilowatts, average amperes, per machine, 296 per phase, and volts 524, which gives a power factor of 0.72.

From 3 p.m. to 5.30 the average total load was only 440 kilowatts, 246 amperes, per machine, volts 530, giving only 0.65 power factor.

In both cases the value is for the generators themselves, including the synchronising current.

A test made during the afternoon with an ammeter measuring the whole current from the three machines, usually read about 5 per cent. lower than the sum of the three ammeters. The load values for the power factor would thus actually be about 5 per cent. higher than those given above, or, say, 0.77 at 580 kilowatts and 0.70 at 440 kilowatts.

Cost of Wood Fuel

The average weight of a "cord of wood" was carefully checked from samples made up by boys and afterwards weighed. Marula wood gave 3,000 lb. and Mapani 3,600. The average, therefore, would be fairly represented by 3,300 lb. to the cord, at an average price of 15s. per cord. Taking the fuel consumption to be, say, 3.6 lb. per unit (kilowatt) generated, the cost works out at less than 0.20d. per unit for fuel.

Water Consumption for Gas Plant

The quantity of water used for the gas plant scrubbers, etc., was carefully ascertained from measured tanks, and was found to amount to 2,850 gallons per hour, equivalent to a rate of approximately 4 gallons per brake horse-power. The temperature of water inlet was 84 deg. Fah.

Gas Analysis and Calorific Value

The official analysis of the constituent gases from the gas plants and their calorific value is given below. The variation in the samples is due mainly to the condition of producers as regards stoking and charging, and illustrates the importance of mixing the gases from the different producers before use at the engines.

[COPY OF GAS ANALYSIS, ETC.]

University College,
Johannesburg,
Feb. 17th, 1922.

To Professor Buchanan,
Johannesburg.

Dear Sir,—The following is my report on four samples of producer gas from Lonely Mine, submitted by you. The bottles were not numbered, so, for convenience, they were given the numbers 1 to 4, according to their position in the basket.

CALORIFIC VALUES (GROSS).

These were determined by direct combustion of a known volume of gas in presence of oxygen. The figures given represent B.Th.U. per cubic foot, at 760 millimetres pressure at 0 deg. C.

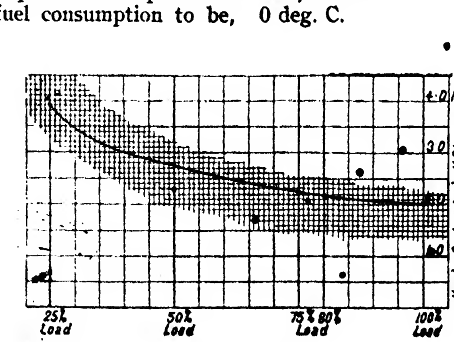
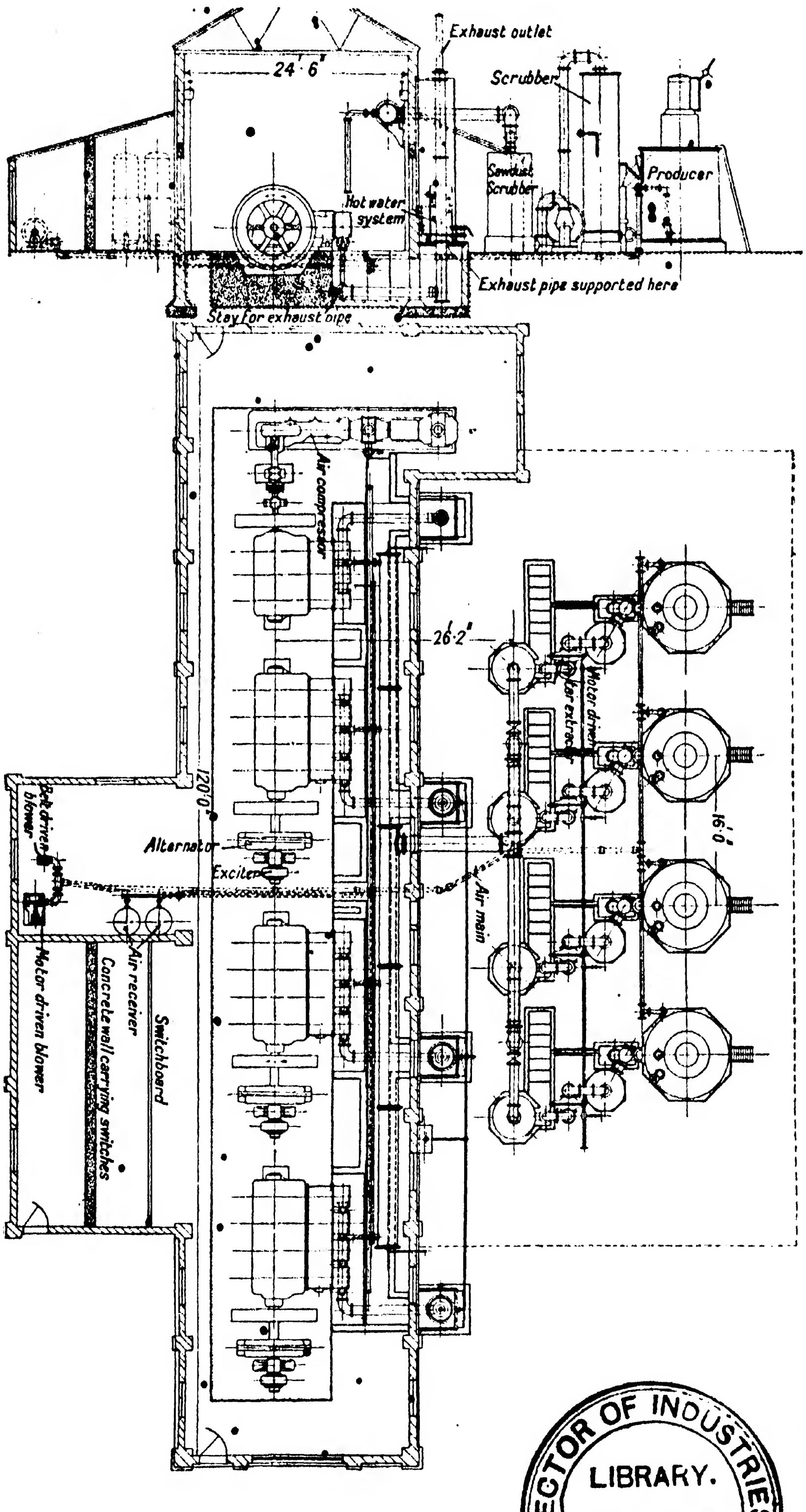


FIG. 6



No. 1	...	...	...	148
No. 2	...	...	...	172
No. 3	...	...	...	160
No. 4	...	...	...	166
Average	...	...	...	161.5

A composite sample consisting of approximately equal proportions from each bottle was analysed by means of a Hompels apparatus, with the following results :—

	Per cent. by volume.
Carbon dioxide	1.8
Oxygen	2.5
Carbon monoxide	22.9
Hydrogen	15.4
Methane	1.0
Olefines (ethylene, acetylene, etc.) ...	Traces
Nitrogen (by diff.) ...	56.4

By calculation this gives a gross calorific value of 142 B.Th.U. per cubic foot. This figure cannot, however, be regarded as being so accurate as those obtained by direct combustion, in the Mahler calorimeter, owing to the limitation of technical methods of gas analysis in determining and differentiating small proportions of hydro-carbon gases.

These results show that the gas is of high standard, somewhat above the average for producer gas.—Yours faithfully, (Signed)

N. B. ADAM.

Concluding, Prof. Buchanan states : "The whole plant seems well able to give its guaranteed output. The engines run remarkably smoothly, with absence of noise, and are of ample capacity for their duty. The producers also appear to have sufficient capacity to enable the normal load to be obtained with one in reserve. Some 200 gallons of tar were produced from the whole plant during the twenty-four hours' test."

The Michell Viscometer

This article has been compiled from data supplied by the agents for the Michell Viscometer, Messrs. Adams Hilger Ltd., London, to whom we are also indebted for the loan of blocks.

EVERY fluid, whether it is a liquid or gas, offers resistance to flow, which is termed its viscosity. Viscosity is the opposite of mobility. It is a property which is independent of specific gravity. Although, generally speaking, the two usually vary in the same order in any one type of oils, yet oils of the same specific gravity may differ very widely in viscosity. Again, although two oils may have the same viscosity at a certain temperature, they may have quite different values when tested at another temperature. The practical importance of this latter fact will readily be appreciated. Viscosity being the most important factor in the lubrication value of an oil, its measurement becomes of prime importance to those having to decide as to the suitability of a lubricant for any specific purpose.

Hitherto the instruments employed for measuring viscosity have been of such a nature as to be quite unsuitable for anything but laboratory use by experienced hands. For scientific purposes most of them make use of Poisseuille's law, in which the rate of flow or efflux through a capillary tube is measured. The method involves a large number of troublesome corrections for acceleration due to gravity, density, mean head, surface tension, etc., etc., but in careful hands it is capable of considerable refinement, with results approximating to absolute values.

The most widely used instruments are the " Redwood " in Great Britain, the " Saybolt " in the United States, and the " Engler " on the Continent, all of which operate upon the efflux principle, whereas in the " Cup and Ball," or " Michell " viscometer, the measurements are obtained in a very different and a much simpler way.

The Michell instrument consists of a cup of steel or cast iron having a perfect concave surface, and is provided with a hollow stem or handle, which forms a thermometer pocket extending into the metal of the cup. The surface of the cup has three minute projections which prevent the steel ball from making complete contact, and regulate the thickness of the film of fluid under test. In order to protect the concave surface from injury, and to accommodate a surplus of the fluid, the cup is slightly recessed all round its edge.

Viscosity is measured by taking the time required for the ball to fall from the inverted cup.

In the usual forms of viscometer the test is made by causing a considerable volume of the liquid (say 50 cubic centimetres) to flow through an orifice or tube 1 or 2 millimetres in the bore. In these " tube " viscometers, therefore, the liquid is drawn out into a thread many feet (usually about 100 feet) in total length. In order that the test may not take too long, for example, not more than 30 minutes, this thread must, of course, move through the tube or orifice at a comparatively high velocity, viz., 1 centimetre or more per second.

In the " Cup and Ball " viscometer, on the other hand, the maximum extent of movement of any particle of the liquid is from the outer edge of the cup to its centre, and the average movement is still less, and only about 0.3 centimetres. Thus, although the test may be made in 30 seconds instead of 30 minutes, the average velocity is only about 0.01 instead of 1.0 centimetres per second, and consequently the amount of energy per unit volume of liquid which is absorbed in producing velocity in the " Cup and Ball " and " Tube " viscometers respectively are about in the ratio of 1 to 10,000, being proportional to the squares of these velocities.

Similarly, the liquid thread of the " Tube " viscometer, while being drawn out to a length of, say, 100 feet, has its surface extended to an area of many hundreds of square centimetres, and the relatively large and uncertain amount of energy required to effect this extension against the action of the surface-tension is, of course, not available for overcoming the viscous resistance.

In the " Cup and Ball " viscometer, on the contrary, the total extension of the liquid surface during the action of

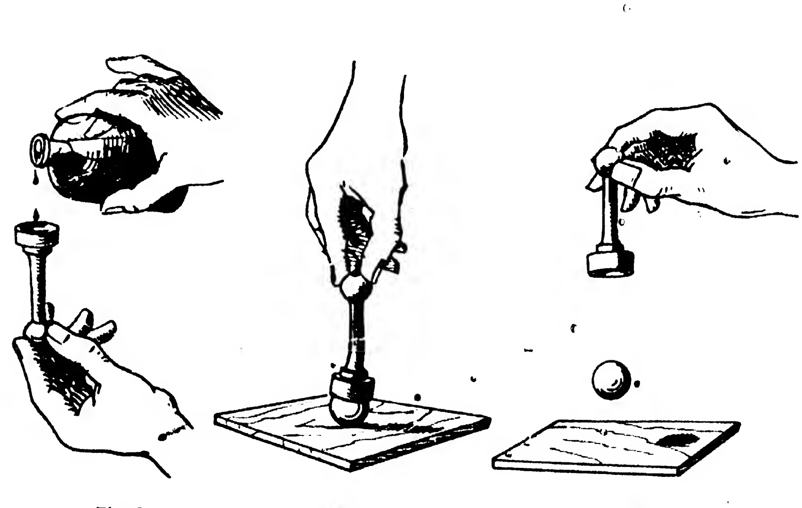


Fig. 3 Fig. 4 Fig. 5

Showing the workshop method of using the instrument

the instrument amounts only to a fraction of 1 square centimetre, and the energy involved is negligible.

In another important respect, the "Tube" viscometer fails to give a true measure of viscosity. The force which propels the fluid through the tube is the weight of a short column of the liquid, and this weight depends on its specific gravity. The resultant motion is, therefore, a mixed measure of the viscosity and the specific gravity, hence the latter must be separately determined before the true viscosity of the liquid can be deduced from the test.

But in the laboratory method of using the "Cup and Ball" viscometer, the force which overcomes the viscous resistance is the weight of the steel ball less the weight of the liquid displaced, which is definite, and for ordinary ranges of liquid density is for all practical purposes constant. Thus the viscosity is determined independently of any other property of the liquid by the Michell viscometer.

The action may be briefly explained as follows :—When its support is removed, the ball, being acted upon by gravity, is drawn downwards. The film, which is of fixed initial thickness, thereby becomes subject to tension ; and, following the law of fluids, it draws the fluid from the circumferential gallery, which is its only source of supply, towards the centre of the cup. The inward rate of flow of the fluid increases the film thickness until the ball falls away, and the rate at which this inward flow takes place is an inverse measure of the viscosity of the fluid.

The workshop method is employed when it is desired to quickly compare the viscosities of several samples of oil at one temperature, and where approximate readings are all that are required. The procedure is as follows :

Sufficient of the oil to be examined (usually about three drops) is put into the cup, so that when the ball is placed in position, the gallery and annular recess is completely filled. The whole is then inverted, and the ball and cup pressed firmly together on a clean board or pad to ensure contact between the ball and the projections in the cup, the instrument being held only by the insulated knob of the handle, so as to avoid heating it. A convenient method is to rest the elbow on the bench whilst applying the full weight of the hand, *i.e.*, 5 or 6 lb., on the knob of the instrument for a time equal to not less than half the time of fall of the ball, as

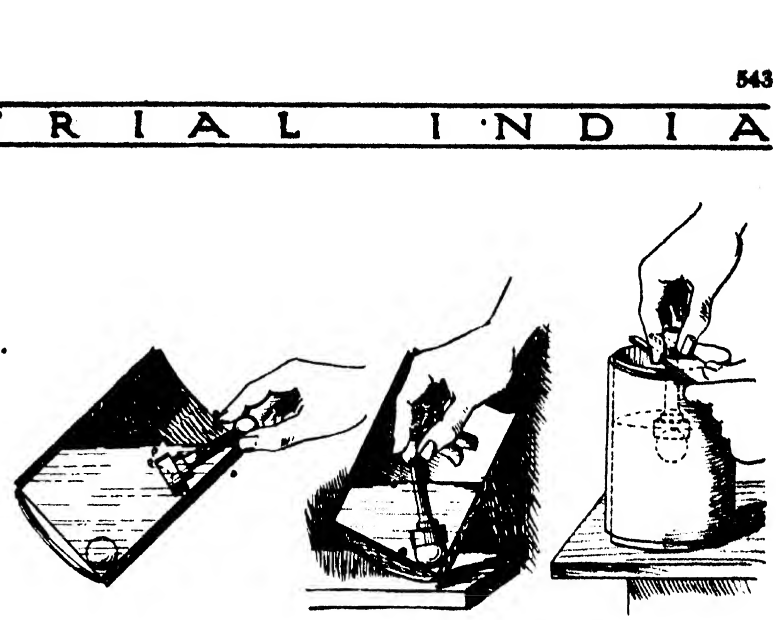


Fig. 6 Immersion method Fig. 7 Fig. 8

obtained by a trial reading. After releasing the pressure for one second the viscometer is raised an inch or so, holding it steady and vertical, at the same moment a chronograph or stop-watch is started and the number of seconds from the lift to the fall of the ball is noted. The time in seconds divided by the constant of the instrument gives the viscosity of the fluid under test in dynes per sq. cm. at the temperature shown by the thermometer in the stem. The operation should be repeated to check irregularities, and the average result taken. In order to establish continuity of temperature between the instrument and the thermometer, a few drops of the fluid to be tested should be placed in the thermometer pocket.

The above method, whilst useful in classifying oils, is limited to the determination of their viscosities at atmospheric temperature. The engineer, however, requires something more than this in order to make an intelligent selection of the best oil to use for a particular bearing. The viscosity curves of the oils must be compared, *e.g.*, if it is thought that a particular bearing, adequately lubricated, is running at too high a temperature, a viscosity curve of the oil used should be plotted, and the viscosity of the oil at the running temperature noted. Another oil is then selected and its curve drawn. If the second oil has a lower viscosity at that particular temperature, then probably it is the better oil to use for the particular conditions. The process should be repeated until an oil is found with which the bearing will run at the lowest temperature.

In using the laboratory method the tests are made with the cup and ball immersed, and care should be taken to work in a situation free from draughts and dust.

A convenient method is to use a small glue kettle (holding, say, ½ pint), and having seen that the inner pan is thoroughly clean, fit a sheet of soft lead in the bottom for the ball to drop upon. Place the instrument in the pot with sufficient of the fluid to be tested to well cover the ball and cup, put a few drops of oil down the stem and insert the thermometer, and put water in the outer pan. The whole is then stood on a Bunsen burner and kept at the boiling point of water for a couple of hours, so as to get every part of the cup and ball to this temperature, then taken off and placed on a table in a good light.

Lower the viscometer with the thermometer in its stem on to the ball, keeping it inclined at an angle of about 45 deg. to avoid trapping air in the cup, press the ball home (as in the workshop method), raise the instrument sufficiently to bring the ball clear of the bottom of the pot, and check the time required for the ball to fall.

The oil should be gently stirred with the viscometer before each observation is made, to ensure that the oil is at the same temperature throughout.

Where viscosities below atmospheric temperature are required, it is better to cool the whole apparatus with ice and take measurements as it gradually warms up to normal.

Where readings above the boiling point of water are required, the inner

VISCOMETER TESTS of "SPECIAL" TURBINE OIL.

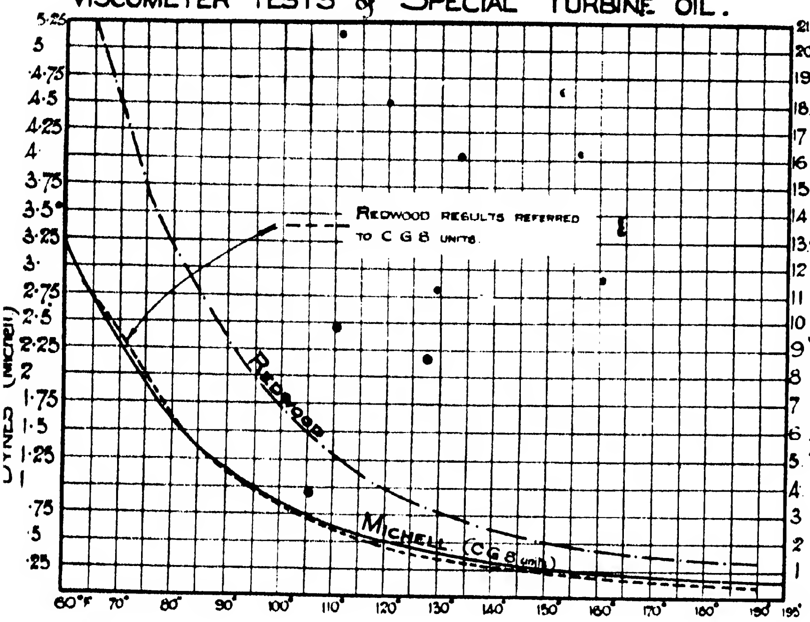


Fig. 9

pan can be used alone, carefully heated up to the required temperature on a Bunsen burner, and the readings taken as the temperature gradually falls, the inner pan being placed in a warm lagged vessel to prevent too quick cooling at the higher temperatures.

Where many tests are to be made, and to avoid using the fingers, it is worth while to provide some simple implement for lifting the viscometer and holding it steady whilst waiting for the ball to drop.

In all cases read the temperature while the instrument is raised, and before the ball drops.

The first two or three readings of a series are apt to be erratic, and ought to be neglected.

Where the fluids to be tested have a fairly wide range of viscosity, it is advisable to use two instruments, one having a high and the other a low constant, the high constant instrument being used for thin fluids and the low for the more viscous. Suitable instruments are supplied in pairs. Generally speaking, it is better to use a high constant (or slow acting) instrument where accuracy is important, provided that the temperature is maintained.

The constant given on the case of the instrument, is that applicable to the laboratory method of use. It can, however, be used with sufficient accuracy in the workshop method, in view of the approximate values required for shop practice.

The whole process of taking a series of readings is exceedingly simple with the Michell instrument. The specimen curve given was completed in two hours, and records 32 readings. The comparative Redwood curve shown required nearly two days to complete, and whilst the Michell curve was drawn through the datum points, that constructed from the Redwood readings had to be faired between the plotted points. Also to reduce the Redwood readings to absolute values took longer than the whole operation with the Michell viscometer.

Foreign Matter

The advantages of expressing viscosity in absolute units instead of arbitrary figures which may bear no relationship even to a true measure of fluidity, will appeal to engineers as the only intelligent method, and one which also affords some quantitative idea of the power lost through defective lubrication. The facility with which a curve of viscosity can be constructed is of the greatest value, since it can at once be seen at what temperature a lubricant ceases to be effective.

In testing crude oils and the like, it is advisable, if possible, to strain or filter the liquid to remove foreign matter. Any solid particles which prevent the ball from making perfect contact with the projections in the cup will, of course, cause the viscometer to give a false result. It is to be noted that whereas solid particles falsify the results obtained with a "Cup and Ball" instrument, giving a value of viscosity which is less than the true value, they also falsify values given with an efflux instrument, giving values which are too large. It is not always possible, however, to remove finely divided solids suspended in the liquids, and in some cases such suspended matter may even be regarded as an essential constituent of the fluid to be tested, as, for instance, in the case of tar or "black" fuel oils containing finely divided carbon.

FORGING A FOURTEEN FEET RING

Among the most remarkable machines to be found in British steel works are the huge mills for forging various gigantic forms of steel. Some years ago, for example, a British steel works installed a hollow rolling mill for forging the large drums required for the slow speed marine turbine then in fashion. Since that date the turbines installed on board ship are much smaller, because they run at a very much higher speed, and obtain the necessary speed reduction by means of gearing. This development, however, brought with it a demand for large gear wheels, and the same plant has been readily adapted to forging the rims of such wheels. The steel is first cast in ingot form and punched under a four thousand ton press. It is then drawn by another press to the desired length and is rolled by a twelve thousand horse power engine to the required diameter. The processes are so designed that they give uniform strength and hardness throughout rims measuring nearly fourteen feet in diameter by over six feet in length. The final weight of each rim is nearly twenty-seven tons, and the forging is so large that it has to be transported by road.

The Development of Water Power in India

The following are some extracts on the discussion which took place at the Royal Society of Arts on the paper read by Mr. J. W. Meares, C.I.E., F.R.A.S., M.Inst.C.E., M.I.E.E., M.I.E. (Ind.).

THE Chairman (Sir Thomas H. Holland) said the author was not entirely correct in assuming that the Industrial Commission showed a touching faith in the omniscience of the Public Works Department. In the first place, the summary of the recommendations of the Commission published with its report, contained a misprint which might seem to reinforce that idea, but if one examined the full text of the report, paragraph 100, it would be found the Commission said that proposals for generating water-power from canal falls and other irrigation works should be considered by a joint committee composed of officers of the Public Works Department and Industries Department—not the Irrigation Department, as stated in the summary. It was not quite the whole story to say, moreover, that the Commission recommended that the Chief Engineer of the Public Works Department should undertake the survey. What they really said was that the survey should be placed under a Public Works officer, of the rank of Chief Engineer, and that it would be necessary to associate with him an electrical adviser. It was said that the question, of whether the Electrical Adviser to the Government of India should peform that office ought to be considered. The Government of India accepted that recommendation, and he thought everyone would agree that their Electrical Adviser carried out his duties very well indeed. The Commission were quite aware, as stated in their report, that up to that time, prospecting for water-power had not been recognised as one of the essential duties of the Public Works or any other Department. The data which were obtained by a circular in 1905, and which the author had described in unflattering terms, were cast in a mould not unfamiliar to those who had attempted to obtain information by the agency of other departments in no way interested in the results. The returns were of the mechanical circular kind, compiled from reports by not over-intelligent but grossly overworked subordinates, who were bored—as they always were bored—by what they regarded as meaningless curiosity on the part of harmless but unpractical scientists. When those returns were brought before him, he put them aside as practically useless. Having had previous experience of answers of the circular order, he turned his attention to other matters, of which there seemed to be, at that time, quite enough to occupy him for the rest of his service as Director of the Geological Survey. The institution of the Industrial Commission, some eleven years later, offered an opportunity of reviewing the question afresh. The development of electro-metallurgical industries during the interval, and their vital importance for munitions, which was painfully evident to them in 1917, altered the whole question. It became obvious from the evidence placed before them by witnesses—the author and others—that the question of utilising the water power of India would soon be forced on the attention of those responsible for the well-being and safety of the country. In the first place, it was obvious that the coal deposits were being depleted to an extent which would give cause for real anxiety, especially in regard to the coal suitable for metallurgical operations, in the near future—possibly within the present generation. The main coal deposits of India contained a very large percentage of ash, and, consequently, a correspondingly low calorific value. They could not be worked to a depth comparable to the coal deposits of Great Britain. There was a depth—comparatively shallow—for coal of the kind in question from which it cost more to raise the coal than the coal would return afterwards in saleable power. In the second place, the exploitation of oil was proceeding at a rate well in excess of the increase in reserves by the discovery of new fields. Ordinary economic demands, therefore, would make the mineral fuel question in India a matter of serious concern even with the development only of those activities which required fuel as a motive force—for the mills, factories and transport services. If anything appreciable took place in the development of metallurgical industries, a fuel crisis would be brought considerably nearer. In the third place, hydro-electric power was wanted, not only to mitigate the demand for mineral fuel; there were some industries of vital military necessity which could be undertaken only, or most suitably, with electric power at a relatively low cost. Unless such industries were taken up soon, the Indian patriotic leaders would discover that neither the reformed Councils nor the spinning wheel were of any defensive value. There was another consideration before the Commission. Imitation, or, more correctly speaking, caricature of European Labour movements threatened the life of the coal industry in India more seriously than the mechanical difficulties of mining. That would be effective in diminishing results by alarming capital which would otherwise be laid out on low grade and new propositions, because of the menace which they afforded. There

were many coal deposits which might not be developed at all on that account. Hydro-electric power had the great advantage of reducing the labour menace appreciably. A striking illustration of that appeared in the papers that morning in a report of the speech of the Chairman of the English, Scottish and Australian Bank. Mr. Andrew Williamson, chairman of the Bank, in reviewing the industries of Australia, pointed out that, but for the wisdom of the Tasmanian Government in utilising their abundant natural water power, zinc smelting would have become as unremunerative as that of other metals, but, by the adoption of a new hydro-electric process for zinc, the principal company in Tasmania had been able to carry on with only a fraction of the men required to run an ordinary zinc plant. The other metallurgical industries of Australia were rapidly succumbing to the demands of labour. The question of labour, therefore, was before the Commission, and helped them to realise the necessity of developing hydro-electric power. Then came the question of agriculture. Agriculture was, at the present time, and must always be, the most important industry in India. The importance of agriculture was the justification of the irrigation branch of the Public Works Department. The conflict between water-power as a fuel and water as a fertiliser was, therefore, brought into prominence, and in that connection technologists, such as the author, came into conflict with the irrigation officers. It seemed to him natural that irrigation officers should regard with some suspicion any innovation which might disturb the regularity of their operations for storage and distribution. The rules, regulations and controlling formulæ used by irrigation officers had been established by long experience, and the average irrigation officer hated with suspicious fear—he might almost say superstitious fear — anything that might conceivably disturb his delicately balanced equation of costs and revenue. Generally, the irrigation officer dealt with large bodies of water carried over wide areas with regard to which very slight differences of level might painfully demonstrate that his equation was what the chemists called a reversible reaction. The sums involved in an irrigation project were so large that no one individual would undertake the responsibility for an innovation of the kind in question. The population depending on the accuracy of an irrigation officer's work was not only great, but, like the body of water itself, in a state of unstable equilibrium. He sympathised, therefore, with the tendency of irrigation officers to conservatism. He sympathised with them when they came into conflict with the enthusiasm of the electrical expert. It must be remembered that if the British, during the process of abdicating their trust—which was the way in which many people read the modern changes which were taking place—left nothing behind them in India but their irrigation works, they would have conferred a lasting benefit on the people of that country. In discussing the terms of their report, and in making the proposal to associate a chief engineer of the Public Works Department with experience of irrigation with the Electrical Adviser, the Commission had considerations of that sort before them. The proposal to put a Public Works officer in charge of the Hydro-Electric Survey might not satisfy the electrical enthusiast, but the Commission had to pay regard to things as they were, and frame their proposals with the knowledge that consideration of irrigation requirements must take precedence of mechanical power. It not only would take precedence, but in a country like India it ought to do so. Personally, he would rather see no manufacturing industries in India at all than reduce the agricultural efficiency of the country. There was room, however, for both, and even opportunity for cheap power to assist agriculture itself. He did not propose to take up the time of the meeting by reviewing the facts described in Chapter 5 of the Report of the Industrial Commission, where figures were given to show the amount of power of the " living machine " at present being utilised for the agricultural operations of India. It was estimated that cattle power alone accounted for something like five million horse-power, and there was also the enormous amount of manual labour performed by the ryot himself. There was any amount of room for the introduction of cheap power for the benefit of agriculture; in some cases by its direct application, where circumstances permitted, and in other cases by the replacing of fuel, and especially oil, which was used in numbers of small oil engines for well irrigation. It was possible, therefore, by a proper blending of those two authorities—the Electrical Adviser and the irrigation officer—to discover some form of action that might be for the general and safe benefit of India as a whole. The author had stated that the hydro-electrical questions had, under the Reform Scheme, become a transferred provincial subject, instead of a central reserved one, and had suggested that that decision was more of a fluke than a result of careful consideration. He would like to point out, however, that the Commission regarded the proposal for a hydro-electric survey as a central subject for the care of the Government of India itself. They proposed that it should be placed under a Public Works officer, and they wished, as he had said, to associate with him the Electrical Adviser to the Government of India. The financial estimates were made on the assumption that there would be one chief engineer for the whole business, and not separate chief engineers for the hydro-electric survey in the separate provinces. The Commission thought they had very good reasons for that proposal. One of those reasons had not been mentioned by the author, but he thought Mr. Meares would agree with it; it was the necessity, in a survey of the kind in question, of organising the collection of data spread over many years, data not only with regard to the flow of established streams, but with regard to variations in rainfall that manifested themselves only after many years of survey. In the case of Canada and the United States, where water operations were under the control of special departments, it was laid down that a number of uniformly taken approximate estimates of flow, spread over many years, were to be regarded as far more valuable than very precise determinations taken over a short period only. That was one of the considerations they had in view in proposing that the subject of the hydro-electric survey should be a reserved and central subject. The report of the Commission was written before the Montagu-Chelmsford Report was issued. The Commission were unaware of the proposals of that report, which, moreover, left the distribution of subjects to be determined by a special committee sent out at the instance of Parliament. The classification into central and provincial, transferred and reserved subjects was made by that Committee. There was, however, something to be said for both sides. There were advantages in central control for the Hydro-Electric Survey, as the Commission had found, just as there were advantages in the

case of the Geological Survey, but, on the other hand, the machinery to be employed was provincial, and it might be held that provincial officers of the Public Works Department were most capable of doing the work, and most conveniently provided with the necessary staff and equipment. It was also, from a political point of view, desirable, possibly, that each province should be responsible for carrying out its own hydro-electric survey. He did not propose to pursue the point further, because it was far removed from the main points of the very interesting paper the author had presented.

Dr. J. F. Crowley, M.I.E.E., said it ought to be very clearly recognised that the hydro-electric survey was only one of the many things which India owed to the foresight of Sir Thomas Holland. It was, of course, very much to be regretted that in the opinion of the author of the paper the work of the survey had ended for the time being. With regard to the results of the survey, the author seemed to be satisfied that from 7,000,000 to 8,000,000 h.p. was available. If that was taken at a load factor of 33⅓ per cent., which was a usual industrial load factor, little short of 26,000,000 h.p. would be found to be available for ordinary industrial purposes. The h.p. at present in use in the United Kingdom for all industrial purposes was only 13,000,000; that in use over the Continent of Europe, excluding England, 24,000,000. That gave some idea of the high value to be attached to the water-power resources of India. There were, however, many difficulties in its employment. In the case of the Tata scheme, the whole of the water to be used throughout the year had to be stored during a monsoon lasting only three or four months. Again, some of the sites were very remote from industrial centres; those on the Himalayas, to which reference had been made, were many hundreds of miles from the important industrial centres in the south. Developments had taken place, however, during recent years in electro-chemical work and electrical work also, which made the development of power sites of the character in question more profitable to-day than they had been, perhaps, for many years. Schemes had been worked out which would enable intermittent power to be used to an extent hitherto undreamed of. One might safely say that the recent developments in connection with nitrogen went further towards solving the intermittent power problem than anything which had been done previously. There was a further development which made the employment of water-power more profitable to-day than in years past. Long distance electrical transmission had been developed enormously of late. When the Tata hydro-electric scheme was projected, 100,000 volts was regarded as a remarkably high voltage, as, indeed, it was at that time. There were schemes under consideration to-day, however, which involved power transmission at 220,000 volts over distances of 250 miles and over, and such schemes were perfectly practical propositions provided the cost of power justified the cost of the transmission lines. As a result of the war, and owing to the work of the Water Resources Committee, British manufacturers had shown commendable enterprise of late in regard to hydro-electric matters. It was no longer necessary to-day to go outside the Empire for material for the pipe lines, hydraulic and electrical machinery, and so on; the whole of the work could be done by big British corporations, which had laid themselves out for the purpose, and their work compared favourably with that done on the Continent and in America. It was painful for a British engineer visiting India to find so many schemes with plant which did not come from the home country, and it was pleasant to know that that condition of things need no longer apply. He would like, in conclusion, to add his tribute to the many given to the work of the Public Works Department of India. One of the reasons why he was strongly in favour of an Imperial Conference being held was that the work of the Public Works Departments in Egypt and India could thus be made available for home engineers, and *vice versa*. If, as a result of the paper some effort could be made to continue the hydro-electric survey of India, it would be a very good thing. He spoke as one to whom the first, second and triennial reports had proved of considerable value, and he, in common with many others, would like to see the survey carried to a reasonable completion.

Dr. J. A. Harker, O.B.E., F.R.S., said that during the last year a great advance had been made with a new nitrogen fixtion process, which seemed to be of very considerable importance for remote water-power schemes in a predominantly agricultural country, where a local supply of cheap fertilisers was important. The chief difference between the new process and those formerly employed was, that in the new method cheap water-power was practically the only *sine qua non*. No raw materials other than water and air and hydro-electric power were required for manufacture of the initial product, which was liquid ammonia. It appeared practically certain from the costs of working already attained, that ammonia could be produced by the new method at a price very much lower than by any other process hitherto employed.

The Chairman said that with reference to Dr. Harker's remarks, one had to be extremely careful about urging the development of nitrogen fertilisers in India. In Behar, at any rate, near the tropical line, nitrifying bacteria produced nitrate of potash in the soil to such an extent that it was exported to an extent of nearly 20,000 tons a year. One should not go out of one's way, therefore, to manufacture an article which nature already provided in excess.

Mr. Frank Noyce, I.C.S. (Indian Trade Commissioner), in moving a cordial vote of thanks to the author, said the fact that local Councils did not vote funds for the continuance of the survey ought not to be put down to any desire on their part not to disturb "the placid, pathetic contentment" of the masses of India. There were two reasons why they had not shown themselves more favourable towards the survey. The first and most important was that they had not got the money; anyone who read the Indian papers knew that the Provincial Governments were at their wits' end to know how to raise funds. The second reason was ignorance. The Ministers and new Councils needed education on the possible results of hydro-electric installations. Whether the new Ministers were worse than the old Members in that respect, the author could probably judge better than himself. At any rate, there had been one Member who possessed far more knowledge of the possibilities of such work than the others, and the meeting was fortunate in having him in the chair that day.

Power Plant at a Telephone Factory

This article is reproduced from "The Power Engineer" (late "The Power User"), by kind permission of the Editor, to whom we are also indebted for the loan of all blocks used to illustrate the article.

THE exigencies of war-time expansion created a position in connection with the power plant of the Sterling Telephone and Electric Company Limited at Dagenham which was far from satisfactory, and necessitated drastic changes when still further demands were made for power. From quite small beginnings the plant had grown, until, within the space originally allocated for an output of 70 h.p., plant capable of generating about ten times that figure had been crowded. It was ultimately decided to erect an entirely new engine house and to rearrange the complete plant upon modern lines, and within the last few months this change-over has been completed. The results that have been achieved reflect great credit upon Mr. W. A. Tookey, M.I.Mech.E., the General Consulting Engineer for the scheme, and Mr. A. Hugh Bourne, M.I.E.E., who was responsible for the electrical side. Mr. J. O. W. Hurd, the Power House Superintendent of the company, gave general supervision and arranged the details of removal from the old to the new building. To all of these gentlemen we are indebted for assistance in the preparation of the following article, and also to Mr. Guy Burney, the Managing Director of the company, and to Mr. Max R. Lawrence, M.I.Mech.E., M.I.A.E., the Works Manager, for permission to visit and photograph the works, and for facilities afforded us in this connection. Mr. A. Newby, Equipment Manager, piloted us round the works and gave us much useful information.

In passing, it may be mentioned that Mr. Lawrence has only recently been appointed to his present position; he is the President of the Institution of Production Engineers, and has been commissioned to increase the output of the Dagenham factory very materially, for which work he is eminently fitted by virtue of extensive experience in mechanical engineering and in the automobile industry.

The main power plant has been erected in a self-contained building, 170 ft. in length and 36 ft. in width, and is run on the lines of a modern central station. It is of the suction-pressure producer-gas type, generating electrical energy at 220 volts direct current, which is transmitted by underground cables to the various distributing centres in the shops. Much of the plant has been re-erected after having seen considerable use in the old power station, but the extensions are of the same type as the old plant.

The fuel used is anthracite nuts of $1\frac{1}{4}$ to $1\frac{3}{4}$ in. in size. This is handled at present by the company's own lorries from the neighbouring railway stations, but plans have been formulated for the laying of a special track to enable the coal trucks to be tipped direct to the storage bunkers. An overhead runway with an electrical hoist and 10-cwt. skip serves the bunkers and producer house; the hoist was supplied by W. Robinson, of Sheffield. Seven producer sets are arranged in the producer house in "herring bone" fashion, and are all of Crossley's open-hearth type. Four of them have been re-erected from their old site, and three of the larger type are new sets. The two producers most remote from the engines are rated at 180 h.p., and the other five are 250 h.p. units. As may be noted upon reference to Fig. 5, some of the sets have twin scrubbers, and others are furnished with but the usual one. The twin sets are those that were in use at the old power house, and were thus equipped on account of restricted head room, a disadvantage that no longer obtains in the new building. In every case the vaporisers are independent from the producers, as is Crossley's standard practice; they work upon the sensible heat of the gas passing from the producer, and incidentally furnish vapour that is to some extent superheated. The gas from the scrubbers of each set passes into a large overhead gas main which is tapered from 24 in. to 18 in. in diameter. Easily accessible valves are provided so that each individual producer set can be cut in or out of service as required. In normal operation the producers

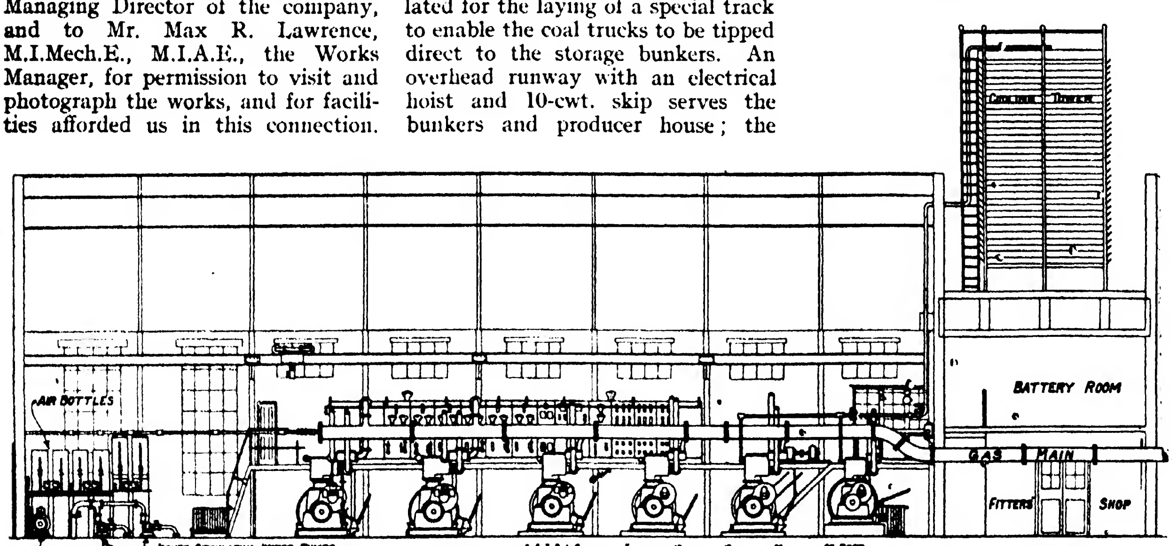


Fig. 4

work under a vacuum of about 2½ in. W.G., which is, however, easily controllable by altering the speed of the Keith, Blackman boosting fan, which supplies the gas to the engines and to the heating furnaces at a pressure of 7 to 8 in. W.G. Two such gas boosting fans are provided, driven by individual 12-h.p. electric motors, but as each fan is rated at 150,000 cub. ft. per hour, and can thus easily handle the entire output of the producers, only one is normally run, and the other is a stand-by. This principle of duplication of the more important details of the plant has been maintained throughout.

From the pressure fans the gas passes into a final scrubber or baffle chamber, before passing into the main gas header that serves the engines. A connection is also provided direct from the fans into duplicate horizontal cylindrical wood wool scrubbers, from whence the gas is taken to the hardening and annealing shops. Its use here has been attended with very considerable success, and has resulted in valuable economy. Separate fans are provided near the points of use in the hardening and annealing shops, so that each shop can be served with gas at a pressure variable at the will of the shop foreman, while in the event of a breakdown of the main pressure fan in the producer house the furnaces will still be supplied with sufficient gas to keep them alight until the stand-by pressure fan is brought into action. As a matter of interest it may be mentioned also that in the event of a shut-down of one or both of the main pressure fans the gas engine plant will continue running, drawing the gas through the fans in much the same way that an ordinary suction-gas plant operates.

Other plant in the producer house includes small motor-driven pumps in duplicate, delivering water to the scrubbers. For the vaporisers softened water is used after treatment in a Permutit outfit rated at 500 gallons per hour. For the scrubbers the water is circulated to and from a filter pond adjoining the building. The tanks, each of 500 gallon capacity, seen in the elevation, Fig. 5, are used in these connections, that nearest the engine room being for the treated water and the other two for the scrubbers. Town water is connected to these tanks so that the stoppage of a circulating pump will automatically bring the reserve into operation.

The main gas supply to the engines is through a 15-in. header running almost the length of the engine room.

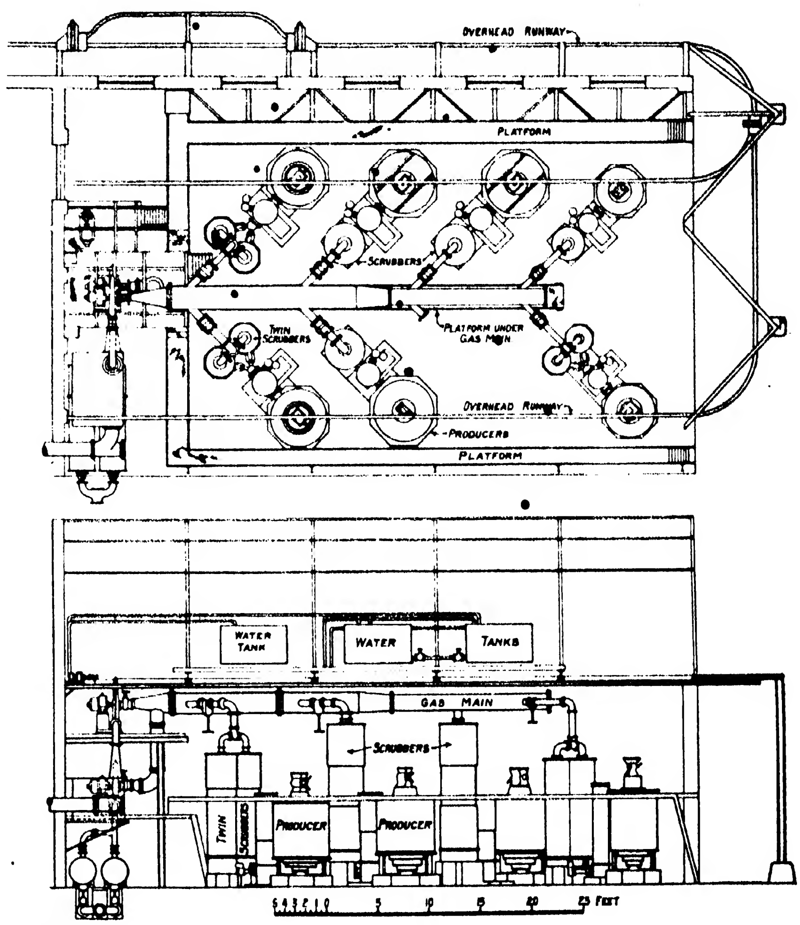


Fig. 5

The generating units that have been re-erected comprise one 80-kw. set running at 450 r.p.m., and three 100-kw. sets running at 430 r.p.m. In addition two new 150-kw. sets, running at 375 r.p.m., have been installed, so that the plant available at present aggregates 680 kw. All of the six sets are of the same type, being four-cylinder engines by Browett Lindley & Co. Limited, direct coupled to Phœnix dynamos. In the case of the last two sets, of course, the dynamos are of the English Electric Company's make, as this firm has absorbed the Phœnix Company. The controls of the gas engines are admirably centralised, so that the driver can adjust his mixture, ignition and other functions, without moving his position. The exhaust from each engine is taken to a silencer outside the building, which, however, is at a higher level than the engine cylinders because it was not considered desirable to take up more space than possible in the roadway along the side of the engine house. The air supply for each engine is also taken from outside, and a neat arrangement has been made for ventilating the crank cases. A pipe is affixed to the top of each crank case nearest the flywheel, and is so bent over the latter that the barring teeth in their rotation induce a current of air into the crank case. Thence another pipe at the other end of the engine framing allows the oily air to be expelled clear of the engine room. Ignition is by Simms' high-tension magneto. Battery and coil ignition is provided for starting purposes, and the point of ignition is at all times under easy control; the provision of a tachometer to each engine enables the operator to know exactly how to obtain correct adjustment. The engines themselves are of simple and robust design, and the fact that repeat orders have been given speaks volumes for their general reliability and satisfactory performance.

Fig. 3

Compressed air is, of course, used for starting, and the bottles, which are arranged together in one corner of the building (see Fig. 3) are pumped up by two small motor-driven compressors, respectively by Reavell & Co., and by Broom & Wade, both driven by 6-h.p. electric motors. Four of the starting bottles are charged with compressed air at 250lb. per sq. in. and the other two larger bottles are stand-by at 300 lb. Special quick opening valves enable any bottle to be charged or discharged at will.

The circulating water system for the engine jackets has been very carefully thought out. A Hudson's cooling tower is provided, over a ferro-concrete tank on top of the battery room, for dealing with this water, and in consequence the jackets are normally flooded, whether the pumps are working or not. A 6-in. suction pipe is taken from the cooling tower tank down to the engine room, and is divided to serve the 3-in. suctions of two Worthington centrifugal pumps, driven by 3 h.p. motors. These auxiliaries may be seen in Fig. 3, and one unit is amply sufficient for all the prime movers. The two discharges are merged into one 6-in. pipe which is taken along the pipe trench in front of the prime movers. Branches are taken for the two largest sets, and after traversing the water jackets the pipes are united again and proceed direct to the top of the cooling tower. The main 6-in. delivery is reduced to 4 in. when it has passed the two large sets, and the pipes for two of the 100-kw. engines are united similarly and proceed as one to the cooling tower. The last two sets are served by a 3-in. main delivery, and have an independent delivery to the cooling tower.

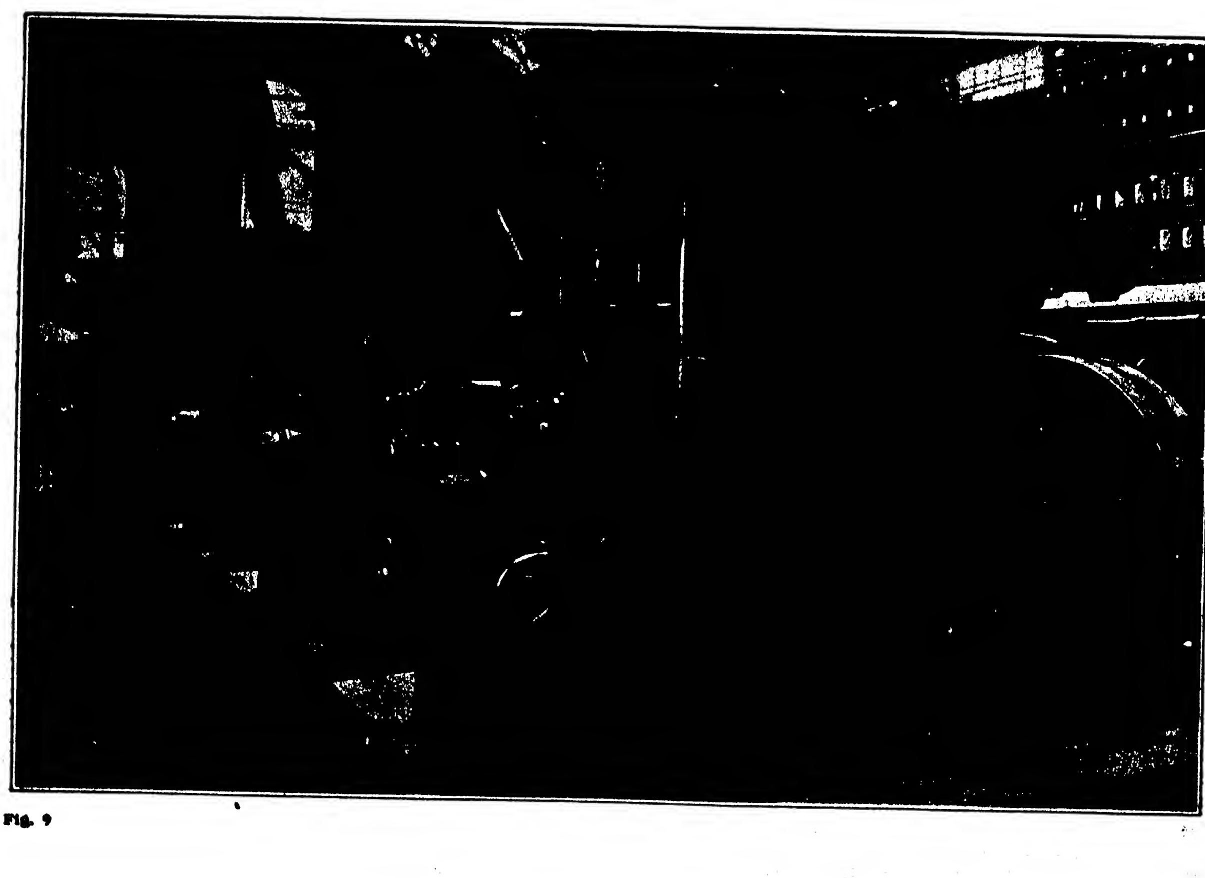


Fig. 9

Fig. 8

By this careful grading it has been made impossible for unequal distribution of the water to take place, and a very efficient cooling system is the result. It may, in passing, be pointed out that although the circulating pumps work under a static head roughly equivalent to the height of the cooling tower tank above floor level, the actual dynamic head required of them is only that due to the height of the distributing troughs at the top of the tower above the tower tank plus the loss through pipe friction. Make-up water is provided automatically from the town main.

The electrical side of the station has several points of interest. The machines are all designed for 220 volts direct current, and are shunt wound. Each set has its separate machine panel, and both the switchboard and the engine room have been laid out to accommodate two more units. A totalising panel is provided between the machine panels and the feeders, and recording voltmeters and wattmeters are installed. In addition, there are two panels to accommodate the battery circuit breakers, regulating switches and booster controls, with charge and discharge ampere hour meters. The battery itself is installed in a separate room above the fitters' shop, between the producer house and the engine room. It has a capacity of 1,000 ampere hours at the 10-hour rating, and was supplied by the Chloride Electrical Storage Company Limited. Its booster for charging purposes is an Electrical Construction Company's machine with a dynamo rated at 160 amperes with a volt range up to 100. Normally, of course, the battery is kept floating on the bars, and it is utilised during

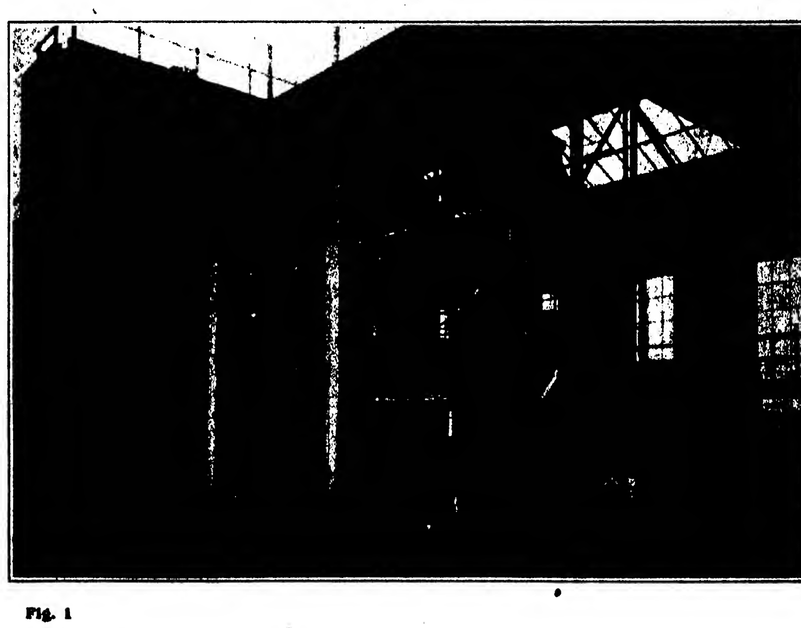


Fig. 1

Fig. 6

be undertaken quickly and efficiently as required. The water supply for the plant is obtained from town mains and does not exceed more than about 40,000 gallons per week for make-up purposes. Town's gas is also available from the mains of the Gas Light & Coke Company for emergency use, there being a 4-in. service pipe connected with the 80-kw. engine.

Conditions of running have been exceptionally irregular since the plant was transferred from the old site. A consistent run has been impossible, mostly on account of labour troubles and similar disturbances. At the time of our visit the prime movers were being run only during the day time, shutting down at lunch time and leaving any night load to be taken by the battery. The units generated per week average about 27,000 with a 20 per cent. load factor, but this, of course, will probably be improved considerably as the factory gets back to more normal conditions of working and expands on the lines already decided upon. Making allowance for the gas used by the hardening and annealing departments, the coal used per unit generated now averages about 2¼ lb., but this, again,

dinner hours and night time when the prime movers are shut down.

There are ten main feeders, each of which is equipped with an overload circuit breaker on the positive and a fuse on the negative. The cables for these are of 0.5 sq. in. section, paper insulated and wire armoured, supplied by Callenders' Cable & Construction Company, and laid direct in the ground. Within the building all cables and pipe work, other than gas mains, air and exhaust trunks and water pipes, are laid in a trench running the length of the engine room, so that a very neat appearance has been attained. The lighting of the engine room is by means of four 1,000-watt gas filled lamps, assisted by local lighting at the back of each prime mover and a strip of "Linolite" along the front of the switchboard. The switchboard and instruments were supplied by Nalder Bros. & Thompson Limited, and the contractors for the whole of the electrical work were Francis Polden & Co. Limited.

The engine room is spanned by a 3-ton overhead travelling crane by Herbert Morris & Co., which enables all erection and dismantling to

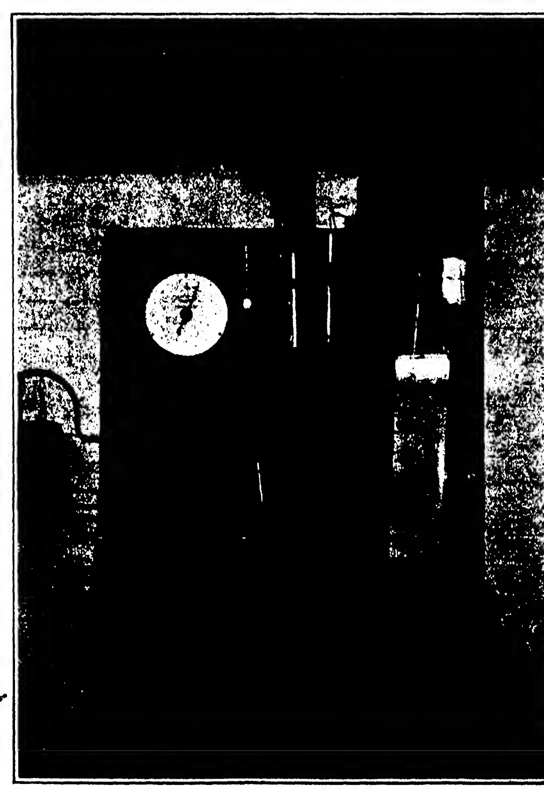


Fig. 7

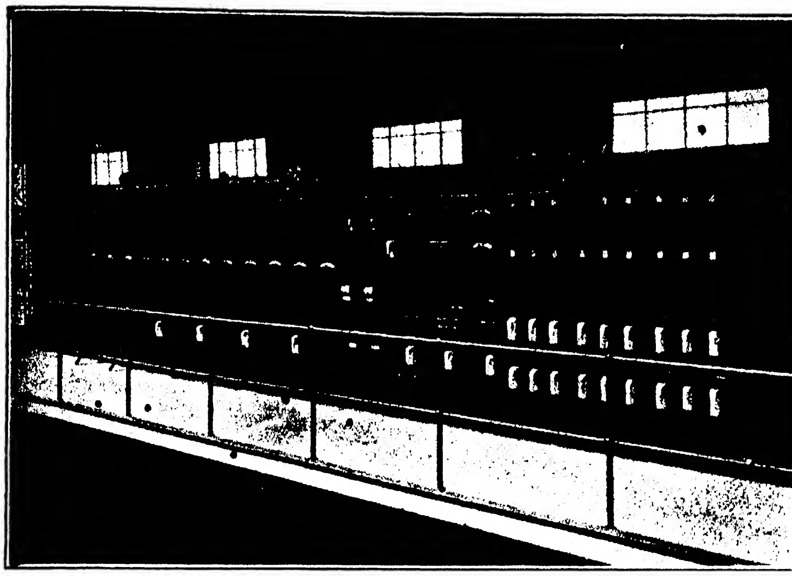


Fig. 2

is capable of improvement under better running conditions. The gas supplied for heating purposes amounts to about 50,000 cub. ft. per day.

A very useful and informative auxiliary has been added on the switchboard gallery in the shape of a recording calorimeter by Alex. Wright & Co. Limited. This is of the Simmance-Abady type, and provides a graphic record of the calorific value of the gas, which averages about 120 to 130 B.Th.U. per cubic foot. It is a combination of a calorimeter and recorder, and thus it is possible to take snap tests at any time to verify the reading of the recorder. In general, the apparatus is of the type recommended for the continuous testing of town's gas, and it is very interesting to note the effect of load and other conditions upon the quality of the gas supplied from the producers.

In several instances lately we have published analyses of various types of gases, and in order to allow comparisons to be made by readers, the following average analysis of two samples of the gas made by this plant will be of interest :—

CO_2	... ...	6.5 per cent.
O_2	... ...	0.9 ,,
CO	... ...	20.6 ,,
H ...	... ...	13.0 ,,
CH_4	... ...	2.2 ,,
N ...	... ...	56.8 ,,

These samples had an average gross calorific value of 128.9 B.Th.U. per cubic foot and a net calorific value of 119.9 B.Th.U.

The application of power in the various shops of the factory calls for no very special comment. It follows on well-tried and standard lines, using direct current electric motors in sizes ranging from 40 h.p. to ⅛ h.p. In many cases the motors are mounted upon platforms or roof trusses, and the first reduction in speed is effected by Coventry chains. The very complete equipment of grinding and buffing wheels is group driven, and special arrangements in the form of suction fans have been made to take away the dust produced ; this is separated in cyclones and does not pollute the atmosphere.

Reheating Compressed Air

The Engineering Experiment Station of the University of Illinois has just issued a very interesting bulletin on the results of investigations carried out by them into the question of reheating compressed air before use. As is well known, in spite of the enormous amount of heat generated during the compression of air, necessitating the use of intercooling plant to obtain any reasonable efficiency in the compressor, the heat in the air when discharged from the compressor is quickly lost by radiation from the air receivers and pipe lines, so that in many cases, especially in mining, when the air actually reaches the source of operation, it is very little higher in temperature than the surrounding atmosphere. Consequently after expansion in the pneumatic tool or other air-driven motor, the reduction in temperature is so great that serious difficulties frequently arise from the freezing of the moisture in the air, and the actual accumulation of ice in the exhaust pipes, in addition to other troubles in the way of cylinder lubrication and loss in mechanical efficiency. These difficulties can be overcome by reheating the air just before use in the motor, so that the temperature of the air after final discharge will remain well above the freezing point of water, and it may be noted also that this reheating process affords a method of greatly increasing the output of power per lb. of air with the expenditure of a very small amount of additional heat.

The results obtained by the University of Illinois show that with the use of a small external combustion reheater, 16.7 per cent. to 61.5 per cent. of the heat supplied to this heater passes into the air, whilst with an internal combustion appliance the efficiency is much greater, 69.4 per cent. to 83.0 per cent. Most of these reheaters employed use petrol as a fuel, and a convenient size is able to heat 250 cubic feet of cold free air per minute to 400 deg. F., the efficiency being about 60 per cent. Exhaust steam or other source of heat may also be used as a heating medium when available in sufficient quantity. The practical advantages of reheating in this way are found to be very great in the way of better mechanical efficiency and improved lubrication in addition to elimination of the ice troubles.

Twenty Years of Diesel Engine Building*

In this interesting record, Engineer-Lieut.-Commander L. J. Le Mesurier reviews the progress made during the past twenty years in the design of the Sulzer type Diesel oil engine.

(Illustrations by courtesy of Messrs. Sulzer Bros.)

SULZER BROS. first acquired the Diesel patents in 1893, but it was not until about 1903 that manufacture was undertaken on an important scale. The first engines were of the four-stroke cycle type, with the well-known A design of column. The two-stage air compressor was operated by a lever from the connecting-rod, and compressor intercoolers were introduced at an early date. The torsion spindle type of fuel valve was used. Between 1903 and 1907 approximately seventy engines of this type were built, ranging in power from single-cylinder engines of 25 brake horse-power up to three-cylinder engines of 750 brake horse-power. Even at this period fuel consumptions of the order of 0.416 lb. to 0.417 lb. per brake horse-power were attained, with a mechanical efficiency of from 75 to 77 per cent. Early in 1904 a marine installation was built, comprising a 50 brake horse-power engine and a magnetic clutch. The arrangement, though expensive and somewhat complicated, worked well and aroused interest in the application of the Diesel engine to the wider field of marine engineering. During this period experiments were continually made with the object of evolving a two-cycle type of engine which would be lighter in weight and simpler from the point of view of the reversible marine engine. The first engine of this type was constructed in 1905. It was a four-cylinder engine of the high-speed enclosed type, developing 100 brake horse-power at 400 revolutions per minute. Valve scavenging was employed, and in the later forms of design the scavenging pumps and air compressors were driven by a separate crank. As in the case of the modern engines, the thrust block was incorporated in the bed-plate.

The three years following 1907 were noted for the development in large two-stroke cycle stationary engines for electric generating stations. Valve scavenging continued to be employed, four valves per cylinder being used. The main design of the

Sulzer 2,000 b.h.p. Single Cylinder Engine

*Some notes taken from a Paper read before the Institution of Engineers and Shipbuilders in Scotland by Engineer-Lieut.-Commander L. J. Le Mesurier.

columns remained unaltered, but the cylinder cover was complicated by the addition of the four scavenging valves. Load on the gudgeon pin calculated on a maximum pressure of 500 lb. per square inch with a pin of 170 mm. diameter, with a total length of 260 mm., worked out at 2,200 lb. per square inch on the projected area. No difficulties have been experienced with these bearings, although the loading would be considered extremely high in steam engine practice. In general, the fuel consumption of these engines was considerably higher than that of similar four-stroke engines, largely owing to the high scavenging presures —5 lb. to 6 lb., per square inch— which were used. Although at this time the results did not justify a strong policy in favour of the two-stroke cycle engine, the possibility and direction of improvements was clearly indicated.

A new design with port scavenging eventually led to the permanent adoption of a modified form of port scavenging patented in 1910, which is now recognised as the outstanding distinctive feature of the Sulzer type of engine. The *Monte - Penedo*, equipped with twin four - cylinder engines of this type, was put into service late in 1912. This vessel, now known as the *Sabara*, has had a chequered career. Up to the August, 1914, she had run 65,000 miles, the only important defect arising from piston heat cracks. The original design of piston has been replaced, and no further trouble has been experienced from this cause. The *Sabara* was interned during the war in Brazil, and was laid up at Messina from 1920 to 1922 owing to legal charter difficulties. The vessel did a further 50,000 miles from the end of the war until the end of 1920. A crank shaft has been replaced, the original design was, it is to be noted, 20 per cent. weaker than Lloyd's standard. The ship is again in Brazilian service.

In order to arrive at a definite idea as to the limits of output obtainable in a single cylinder, early in 1914 an experimental engine was built with a cylinder of 1,000 mm. bore by 1,100 mm. stroke. Exhaustive experiments on scavenging with upper and lower ports were carried out, the trials of this engine being supervised by Dr. H. Stodola. The cylinder head rests on four columns of forged steel, and the cylinder is suspended from the head in such a way as to be capable of expanding freely downwards. Heavy cast-iron columns secure transverse rigidity and carry the four slipper guides of the symmetrical crosshead. All working loads are taken by the steel columns, thus relieving the cast-iron framing from tensional stresses. Considering that the total working pressure on a piston of these dimensions amounts to over 300 tons, the problem of designing both framework and running parts, particularly the gudgeon pin bearings, was a formidable one. The records of the trials made with upper row of scavenging ports blanked off and the lower ports only used for scavenging air showed that there was a considerable loss in output and efficiency when scavenging takes place through the lower ports only, and confirmed many other similar experiments with smaller engines as to the advantages of having an upper row of scavenging ports controlled by a valve. The most important effect of these tests was, however, to inspire confidence in the possibility of dealing with the heat stresses and

designing satisfactory mechanical arrangements of engines of any power that might reasonably be required either for marine or stationary installations.

At the beginning of 1915 two large marine four-cylinder engines of 1,600 brake horse-power, along with auxiliaries, were tested by Dr. Stodola. The war prevented these engines from being installed in their ship, but the test bed results show that even ten years ago there was no difficulty in dealing with the essential problems of a marine Diesel engine developing on overload 500 brake horse-power, or 750 indicated horse-power per cylinder. The dimensions of these engines were as follows :—Four cylinders, each 680 mm. bore by 960 mm. stroke, designed to develop 1,600 brake horse-power at a speed of 110 revolutions per minute. The fuel consumption of 0.479 lb. per brake horse-power hour with a scavenge air pressure of 3.1 lb. per square inch is higher than with present-day engines, owing chiefly to the improved scavenging. The engines for the *Camranh* have the same diameter of cylinders, but with scavenging blowers, and the test results last year gave a figure of 0.411 lb. per brake horse-power for the fuel consumption with a scavenging air pressure of 1.5 lb. per square inch.

Although engines of the four-stroke cycle type continued to be built in sizes up to 1,000 brake horse-power, all engines above this power were exclusively of the two-stroke cycle type, and considerable progress was made in standardisation of details and a reduction in the cost of manufacture. The experience gained in the construction of large power units of this type up to 1915 may be gauged by the fact that up to this date twenty-four engines, representing a total of 27,400 brake horse-power, were supplied. These were three and four-cylinder engines in units from 750 to 2,000 brake horse-power.

A six-cylinder unit developing 4,000 brake horse-power was built in 1915. The cylinder dimensions were 760 mm. bore by 1,020 mm. stroke, and the power was developed at a speed of 132 revolutions per minute. Some progress was made with the automatic control of the injection air to meet variations in the electrical load, a special governing device being employed. Although many of these large engines were employed in generating stations, a study of the design and working of such engines will well repay the marine engineer.

The motor passenger liner of 13,000 brake-power now under construction at the Fairfield yards represents a notable advance in the progress of the motor ship. Being a four-shaft ship, the engines themselves are of comparatively moderate power, and all the essential problems have long since been dealt with and solved satisfactorily. It is perhaps interesting to speculate upon the maximum power per unit that may be obtained without taking either undue risks or departing from the general design of single-acting two-cycle Sulzer engines already described. As the machinery installations of all merchant vessels, with the exception of fast passenger liners, will certainly fall within this maximum, it is proposed to examine a project for a naval vessel having four shafts and developing 40,000 brake horse-power with eight-cylinder engines running at 170 revolutions per minute. The proposed machinery would be as follows :—

	Main engines.	Auxiliary engines.
Number of engines	4	4
Number of cylinders per engine	8	4
Diameter of cylinder, mm.	850	470
Stroke of cylinder, mm.	1,100	600
Brake horse-power per engine	10,000	1,000
Indicated horse-power per engine	12,600	1,430
Revolutions per minute	170	240
Piston speed in feet per minute	1,230	945
Indicated mean pressure, pounds per square inch	94.5	92

The turbo-blowers and cooling water pumps are electrically driven, and absorb per main engine approximately 700 brake horse-power, supplied by the auxiliary engines.

The total weight of the main and auxiliary engines, turbo-blowers and pumps with their motors, air reservoirs, compressors, silencers, etc., amounts to about 2,750 tons. The weight is thus 150 lb. per brake horse-power, which compares with about 70 lb. per brake horse-power for submarines, and 290 lb. per brake horse-power for ordinary cargo vessels fitted with Sulzer two-cycle main and auxiliary engines.

The second table shows a comparison with the proposed design embodying the following engines :—

(1) Stationary engine of 4,000 brake horse-power with six cylinders, completed in 1915, having direct-driven scavenging pumps. With separate electrically-driven scavenging blowers the power would be 4,500 brake horse-power when working with the same indicated mean pressure, and for purposes of comparison this power has been assumed.

(2) Submarine engine of 3,500 brake horse-power having eight cylinders, with separate electrically-driven scavenging blowers. This engine developed 3,745 brake horse-power while on trial in 1920.

(3) Standard marine engine of 2,000 brake horse-power, having four cylinders and separate electrically-driven scavenging blower.

Type.	Stationary.	Submarine.	Cargo vessel.	Proposed engine.
Weight of one main engine in tons ...	344	74.5	204	525
Weight of one corresponding auxiliary engine without dynamo...	—	16	17	67
Brake horse-power (total)	4,500	3,500	2,000	10,000
Brake horse-power per cylinder	750	435	500	1,250
Revolutions per minute	132	300	100	170
Cylinder diameter, mm.	760	540	680	850
Cylinder diameter, inches	30.4	21.3	26.8	33.5
Cylinder stroke, mm.	1,020	570	1,200	1,100
Cylinder stroke, inches	40	22.4	46.5	43.4
Piston speed, feet per minute	885	1,120	790	1,230
Indicated mean pressure in lb. per sq. in.	94	100	93	94.5
Weight of engine in tons per cubic foot of stroke volume	3.42	2.02	3.30	2.98

Modern Gas Producers

The following is a brief Review of some recent developments in the design and construction of Gas Producers, and deals particularly with a new design embodying new features which have been evolved after considerable practical experience.

APART from the development of the small suction gas plant to use waste vegetable matter such as wood in the form of either logs, shavings, saw-dust, etc., and also such materials as nut-shells, bark and like matter, the development of the gas producer cannot claim to have made any considerable advancement during recent years, and the original principles embodied in the early producers are still retained to the present day.

At the present time, however, certain radical changes in design are contemplated, and a very considerable amount of experimental work on a large scale has already been carried out, with the fundamental idea of course, of making the gas producer a more efficient commercial unit.

The most radical departure from orthodox practice is the producer which has been styled the R.G., and this new design has been evolved by Mr. T. Rolland Wollaston, M.I.Mech.E., by whom a number of important patents have been secured. Mr. Wollaston has very kindly supplied us with particulars of the work which has so far been caried out on one of these producers, working at Fishwick Dye Works in Lancashire, and we cannot do better than reproduce the greater part of this matter in Mr. Wollaston's own words.

For the information of our readers we had better record that Mr. Wollaston has had a very considerable experience in England with the practical working of the Mond type of gas producer, and his present design is very largely the result of his experience gained in the actual practical working of the Mond type, and he has also been fortunate in securing the services for his experimental work of Mr. Charles R. Windiate, under whose charge Mr. Dowson's classic experiments, and later Mr. Quintin Moore's were carried out.

These facts combined with the obvious conservative attitude adopted in Mr. Wollaston's report, we think, make it very clear that his design will open up, and give a new lease of life to the gas producer for using ordinary bituminous coal.

It is a well-known fact that one of the principal reasons why the Mond type of producer is not more efficient, is because of the very large amount of steam which has to be passed through the fuel bed in order to keep the temperature sufficiently low to prevent the destruction of the ammonia. It will be seen that in the R.G. producer this difficulty is overcome in a scientific manner, in fact from the report it will be seen that in the experimental plant this particular point was actually overdone. Another feature which should be specially noted in this design is the combined gas outlet and retort, which is probably the principal feature in this new producer, enabling almost any class of bituminous coal to be utilised satisfactorily.

We will now re-produce Mr. Wollaston's own description of the R.G. plant, which describes quite clearly its construction and the work so far which has been done on experimental plant.

"The R.G. gas plant is devised under four British and three American patents with a view to eliminating

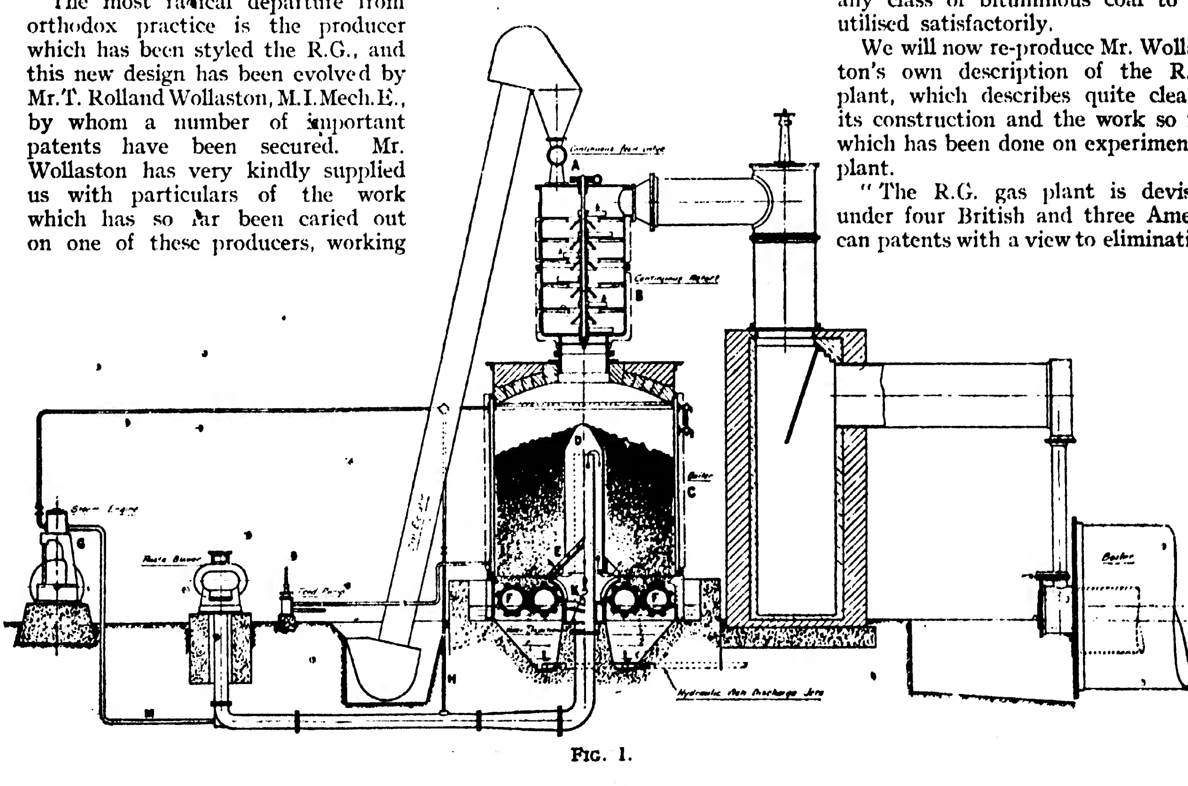
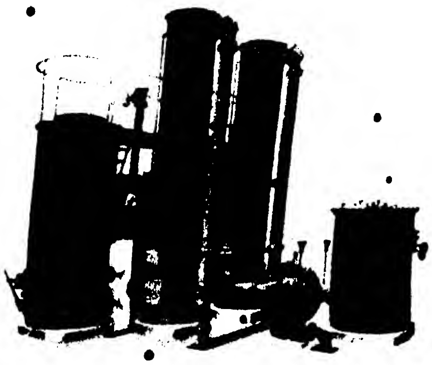
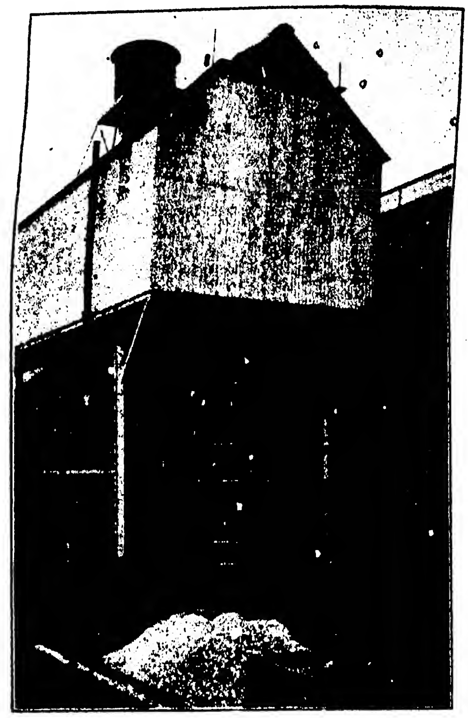


FIG. 1.



Bituminous Suction Plant *The Campbell Gas Engine Co. Ltd*



Wood Refuse Plant *The Campbell Gas Engine Co. Ltd.*

so far as possible all the faults of the older systems. It has proved capable of giving results exceeding all original expectations.

"It may perhaps be described most readily with the aid of a diagram which represents to scale the demonstration plant built. This plant is at work at Preston. It is not equipped with apparatus for the recovery of ammonia nor tar products, but it is practicable to test the gas for potential results in these respects. The gas made is, as a matter of fact, consumed in boilers which provide steam for the adjoining Dye Works. (See Fig. 1.)

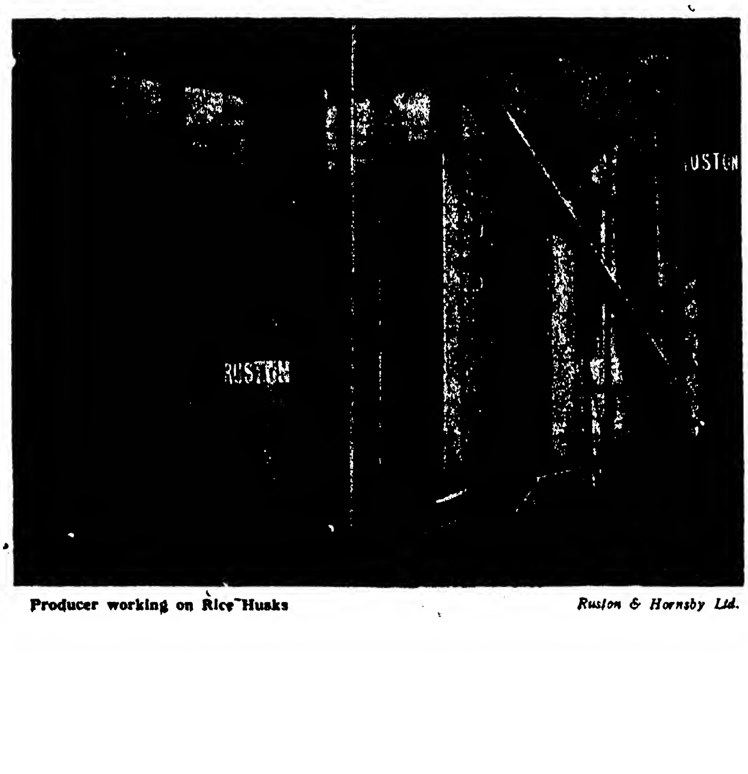
"*A* is a mechanically fed (controllable speed) coal hopper.

"*B* is the combined gas outlet passage and retort (British patent 113856 and a later application).

"In this the fuel, maintained open and in constant movement, has direct contact with the hot outgoing producer gas during a considerable period of time. The fuel travels downwards from shelf to shelf under control of slowly moving spiral rakes and is finally dropped symmetrically into the producer C as coke or semi-coke. The gas entering the retort at a temperature approaching 600 deg. C. picks up the more volatile distillates, becoming thereby considerably enriched both as regards thermal value and potential by-products.

"*C* is the gas producer. It is unlined or only partially lined with refractory material and is surrounded by an annular water space or boiler in which a considerable volume of steam is generated. The producer is fitted with a normal type "Duff" grate but has in addition a central shaft to the upper part of which the air blast from the roots blower is introduced. A water spray is introduced at K. The shaft D becomes sufficiently hot at and above the incandescent zones to vapourise the water injected and to superheat the blast sufficiently for the highest yields of ammonia, (British patents 12400/14 and 111964). It will be noted that the fuel in the producer is radially near to usefully absorbing heating surface inwards and outwards whereby the temperature is kept low independently of the introduction of direct steam.

"The fuel bed does not, as is usual in water bottom producers, rest upon ash piled in the water but is carried by crusher rolls F which rotate very slowly inwardly under simple mechanism at controllable speeds or may be stopped. The device enables the operator to draw ash selectively from any segment of the producer. Ash and clinker (if formed) are broken small and discharged into the specially shaped water lute whence they are propelled (in the case of a battery of producers) by water circuletion,



Producer working on Rice Husks *Ruston & Hornsby Ltd.*

under the action of a low duty centrifugal pump to a central sump and mechanically elevated therefrom. The ash handling is entirely mechanical. The portion of the apparatus is covered by British patent 113025 and by a further application dealing with important improvements, rising out of experience gained.

"A typical analysis of the gas consistently obtained is:—

		per cent.
Carbonic oxide (CO)	... ...	17.1
Hydrogen (H)	... ...	24.3
Methane (CH_4)	... ...	3.9
Carbonic Acid (CO_2)	... ...	10.5
Nitrogen	... ...	44.2
Total combustible constituents	...	45.3
Gross value B.Th.U. per cubic foot...		182.9
Net value B.Th.U. per cubic foot ...		164.9
Ample steam is made for blast and auxiliaries.		
Blast saturation	... ...	74 deg. C.

"There is probably no clearer way of illustrating the comparative thermal value of plant of this description than by three diagrams, and one is given as closely as can be approximated from average data available in fig. 2.

"This diagram shows only thermal comparisions and is unfair alike to the normal and R.G. plants in that it ignores the rebate due to recovery of by-products, particularly ammonia. The price of ammonium sulphate at the time of writing is £14 per ton and the yield from average coal in both normal and R.G. plants may be taken as 80 lb. per ton of coal gasified, that is to say a gross rebate of 10/- per ton on the price of coal. But there are necessarily charges against this—costs of acid and extra stores, extra labour, and capital charges on the added recovery plant. These would be easily covered by an allowance of say 7/- so that in estimating a net return of 3/- per ton of coal fed to producers due to sulphate recovery one would be on a very safe basis. Assume also for purposes of comparison that the average price of coal is 15/- per ton; then the net rebate is one-fifth of coal cost.

"The diagram fig. 3 is worked out on exactly similar lines, except that the yields are based upon 'shilling value' instead of "British Thermal Units.' It will be seen that, from the 'cost' point of view the R.G. plant may be expected to return the whole heat value of the fuel, with a margin.

"It should be noted moreover in the R.G. plant, due to pre-retorting the fuel and other causes, that tar products of superior quailty, capable of distillation to produce good yields of fuel oil and pitch may be expected.

"No experiments in this direction have yet been practicable.

"Hitherto, reference has been made only to the purely chemical and physical features of the R.G. apparatus, and complete demonstrations of all its possibilities still remains to be accomplished. It is apparent that, for different services, there is great elasticity in these respects, that the best prportions for steel works producers would not be the best for an Industrial Gas Distribution Scheme, for example.

"But the outstanding advantages of the new system, as demonstrated by the experimental plant, are of the severely practical class, those which, it will be generally agreed, are most needed. They may be outlined as follows:—

"(1) Any coal hitherto regarded as unsuitable for producer work due to coking or sticky qualities or physical structure can, by reason of the pre-coking, be used without the least

IN THERMAL UNITS.

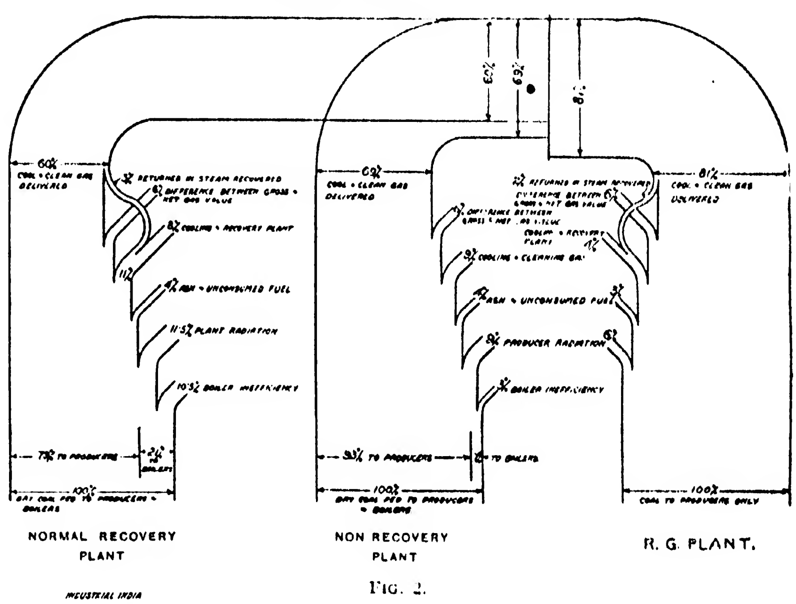


FIG. 2.

IN MONEY.

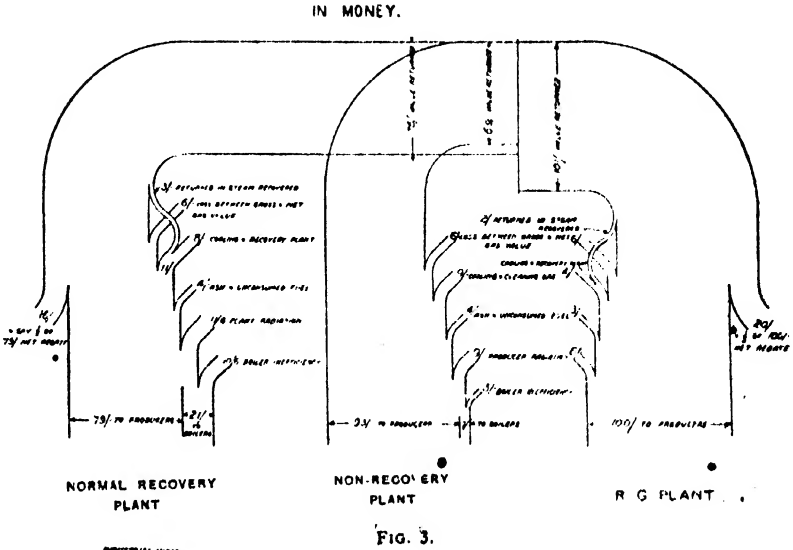


FIG. 3.

Open Hearth Type — The Campbell Gas Engine Co. Ltd.

difficulty and without skilled attention in the R.G. plant. There has never been any tendency to 'arch' nor to form clinker in the producer which, with a net area of about 60 sq. ft., gasifies easily 13 cwt. of coal per hour.

"(2) As regards the crusher roll grate the power given, by selective discharge of ash, to maintain good zoning in the producer will probably appeal to all experienced charge engineers, and the obvious simplicity and certainty of the automatic ash discharge eliminates one of the most costly limitations of earlier installations of large size.

"(3) The retort on the experimental plant at Preston is smaller than it should be for best results. In pre-coking it reduces the temperature of the outgoing gas 150 deg. C., independent upon the working conditions of the moment. Obviously this reduction when cleaning and cooling plant follows, will reduce the size and capital cost of these producers. A further point, unexpected but clearly of great value, is that the retort is found to act as a most efficient filter as regards dust.

"No tests for cleanliness have yet been made, but the gas coming over from retort at about 350 deg. C. appears to be substantially dust free. If this feature is maintained it should be of great value in firing regenerating furnaces and for like purposes. Incidentally, it has been suggested that the higher value gas to be obtained from better proportioned plant may enable continuous recuperative furnaces to replace regenerative furnaces for many purposes.

"As regards operations in which gas producers are now in common use little need be said here. For furnace work generally, for gas engines, and like uses it is submitted that the R.G. plant will prove superior to its predecessors as regards high thermal efficiency and low capital and maintenance costs.

"But wider possibilities are suggested:—

"(1) One of the most prominent consulting engineers (for towns gas plant) in the country has suggested that, on the high thermal efficiency and high calorific value promised by the experiments so far carried out, there is no practical reason why R.G. gas should not supersede water gas as a diluent for town gas, and every economic reason why it should. In his view the dovetailed advantages of combined retort and recovery producer installations at Towns gas works are obvious.

"(2) Many experts have advocated the distribution of producer gas for industrial purposes in busy manufacturing centres. The well-known South Staffordshire Mond Gas Co. though inaugurated at an early stage in the development of the gas industry, and handicapped in many ways, has conferred an estimable boon upon the district it serves. The gas engine, for small and moderate powers, still remains outstandingly the most economical motor. An estimate very conservatively prepared, illustrates beyond question that in a certain industrial district the substitution of R.G. gas for the retort gas now distributed would reduce the power and heating costs of that district by 70 per cent. and there are similar districts in the country.

"(3) It is not suggested that, at the present time, the use of producer gas would directly reduce electricity charges. It is generally accepted that the gas engine is impossible for large power stations. The large gas turbine, if it ever comes, may change this. Coal-fired boilers, working with steam turbines, may average 75 per cent. thermal efficiency. Assuming 80 per cent. gas plant efficiency and 85 per cent. gas fired boiler efficiency, the combined all round gas firing efficiency could only be 68 per cent. By-products would help this figure from the financial standpoint, but it must be admitted at the moment that the direct showing is not very attractive. If however, broader views be taken, if for example gas and electricity interests could combine, to gas-fire boilers and distribute cheap gas for industrial and domestic service, open grates and ordinary furnaces being vetoed, we should approach those conditions of smokelessness, healthfulness and brightness which are so often foreshadowed in public speeches by welfare workers. We should have the satisfaction moreover of knowing that we are no longer deliberately wasting our most valuable natural asset—coal. This may appear visionary, but the writer (Mr. Wollaston) firmly believes not only that we shall have these conditions within the next twenty years, but also that they will be developed to a point of economic soundness.

"In conclusion one would like to draw comparisons between the methods herein described and other methods of dealing with fuel supplies, for example low temperature carbonisation and the production of smokeless fuel, pulverised fuel firing and the like. This statement has however, run to considerably greater length than was originally intended. The writer (Mr. Wollaston) would only add that, in his opinion, there is abundant scope for all these, but he would at the same time plead for more selective discrimination than has hitherto been shown even by so-called experts. The truth, as it appears to him, is that most systems of dealing with coal now advocated are based upon sound scientific facts and that they are capable of dovetailing together to meet any and all public demands."

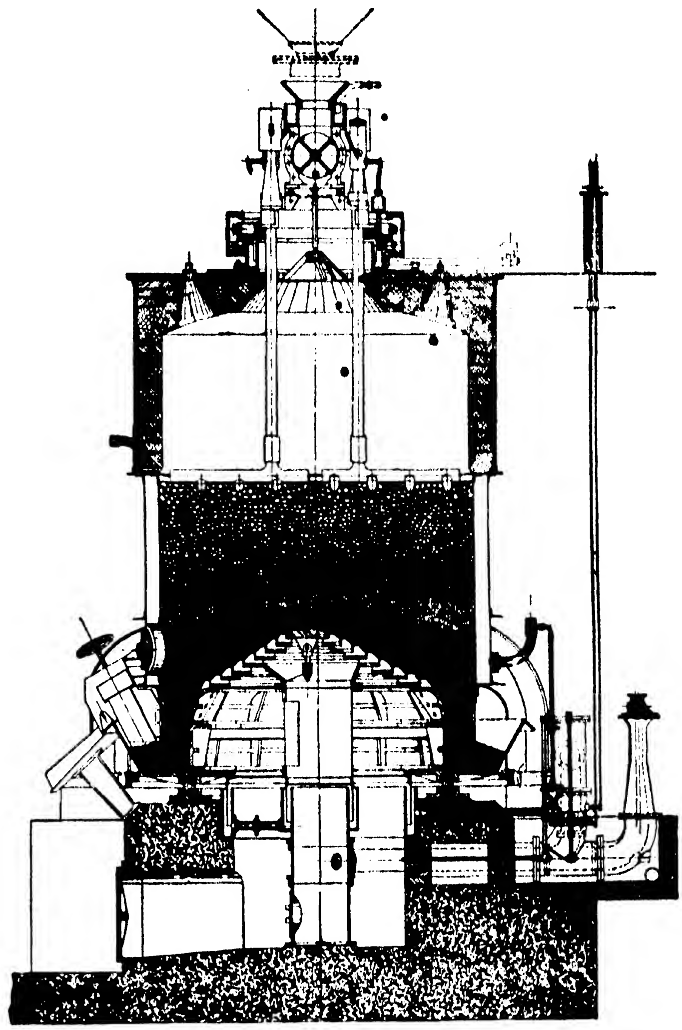
Turning now to the Mond gas plant, in our last issue Mr. David Brownlie dealt very fully with the new design of producer by the Power Gas Corporation Ltd., so there is no need for us to deal with this development fully in the present article. We would however, remind our readers that the Power Gas Corporation Ltd., have set themselves rather a different problem

to that of Mr. Wollaston in their new producer; that is to say, that they aim primarily at low temperature carbonisation conditions for the recovery of large quantities of oil fuel rather than the recovery of ammonia in the form of sulphate and it would appear to us that there are very considerable openings for each of these policies, the adoption of either being a question of market values and local conditions, but the recovery of sulphate must always be a matter of considerable interest to India, which we think is very generally realised.

Our illustrations also show some of the more orthodox designs of gas producers each of which have their own particular field, and the recording of these here will perhaps give a better perspective of the new developments than would be obtained if they were dealt with alone.

We must, however, point out that the suction type of producer is confined to the smaller size plants, whereas the gas plant using bituminous coal has alone catered for larger power plants, that is to say, that the two types cover two discinct fields of application.

We illustrate some of the standard plants made by the Campbell Gas Engine Co. Ltd., including this firm's "Open Hearth Suction Gas Plant" which has been very successfully used for using such fuel as anthracite, coke, and locomotive steam box char, in very small sizes. In this plant it is claimed by the makers that anthracite coal or coke can be used only large enough not to pass through a sieve of ⅛ in. mesh, and the design of the hearth, as will be seen from the illustration, is such that poking and removal of clinker can be done without disturbing the process of gas production, and as a result the plant can be kept continuously at work for long periods.



Kerpely Producer — E. G. Appleby & Co. Ltd.

Another illustration shows the Campbell suction gas plant for using wood refuse, and this particular design in common with those of a number of other leading British firms, has proved to be a very successful method of utilising such material as saw-dust, shavings, chips, rice husks, cork refuse, cotton seed waste, cotton stalks, etc., and converting such material into combustible gas which is an eminently satisfactory fuel in a gas engine cylinder.

Messrs. Campbell Gas Engine Co. Ltd., state that the consumption of dry fuel used, composed of say, 13 per cent. bits, 31 per cent. chips or shavings and 56 per cent. sawdust, is about 2.25 lb. per b.h.p. per hour. When the fuel contains moisture, however, this might go up to 31 lb., but in no case should the amount of moisture in the fuel exceed 50 per cent.

We also illustrate the Campbell suction plant which has been designed for using bituminous fuels, but it should be pointed out that with this type of plant only fuels known as non-coking or only slightly coking, such as collie coal, lignite, brown coal, etc., are suitable. But with this class of fuel the plant is an eminently satisfactory unit, and the general construction and method of working apart from the producer is very similar to other types of suction gas plant.

Another interesting type of suction gas plant which has been developed wholly for using waste fuel and waste vegetation, is that manufactured by Messrs. Ruston & Hornsby Ltd., and it will be noted that the general arrangement of the plant is similar to other makers, but the design of the producer itself is rather different and provides special arrangements for keeping the flues near the producer clear of tar, and is also well supplied with pokers for keeping the fuel bed solid. The main feature, however, of this type of suction plant, is to provide for a large fuel capacity in the upper part of the producer, and this will be clearly seen in both the Ruston and Campbell designs.

In concluding this brief review we illustrate the "Kerpely" gas producer made by Messrs. E. G. Appleby & Co., of London, and we do so in order to put on record a development in producer details which has made very considerable progress both in America and on the Continent during recent years, although it is only quite recently that the matter seems to have taken up seriously in England.

It will be noted from the section of the "Kerpely" producer that the main functions are carried out mechanically, that is to say, the fuel is fed mechanically—the fuel bed is agitated mechanically, and the ash and clinker are automatically removed from the lower portion of the producer.

The removal of ash in this design also embodies a crushing process, the grate itself being placed eccentrically, and by this arrangement the revolving of the grate crushes any large lumps of clinker which would otherwise not pass to the ash pit.

The principal claims for these mechanical features are greater output; gas of higher and more regular heat value, and also, where a number of producers are installed there is a considerable saving in labour.

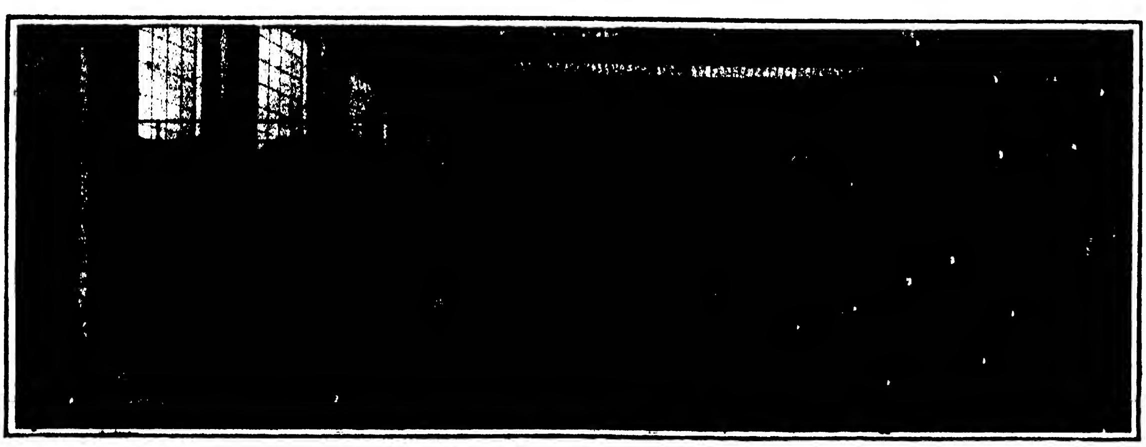
Modern Gas Engines

In the following brief review we put on record some of the principal features in the design of British gas engines which are not specifically dealt with in other articles in the present issue, and we also record some notes on using waste heat.

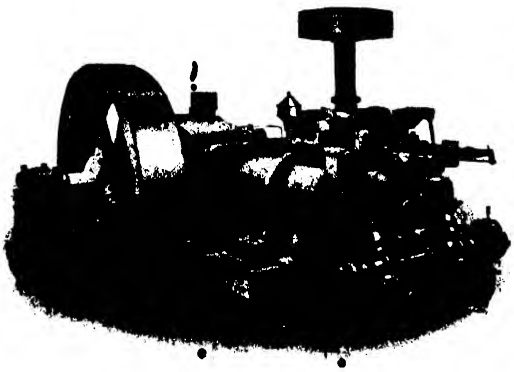
THE general practice amongst British gas engine makers has been to adopt the four stroke principle where gas is used as fuel. The difference in the details of the makers therefore, is one of difference in constructional detail, and there are naturally a number of points on which most British makers seem to be agreed. We therefore propose to only touch on special features which are more or less distinctive of each particular make as we believe that those points which are common to most makers are now fairly familiar to our readers, and they are factors which a lengthy experience has satisfied the British manufacturer that they are perfectly sound practice.

In dealing with the vertical type of gas engine it is worth recording that British engineers have been the pioneers in this field, and although the vertical type has not come into very general use so far, nevertheless it has been very largely adopted for different classes of work, notably for direct coupling to electric generators, and also for direct coupling to centrifugal pumps.

In dealing with this subject it is advisable to remind our readers that where gas engines are under consideration, or any other type of internal combustion engine, it is necessary to remember that the altitude at which an engine works affects the power output of this type of prime mover very considerably, and as a rough guide it may be taken that the horse-power of any gas engine will be reduced by approximately 3 per cent. for every 1,000 ft. at



11,500 B.H.P. in one Engine House — *The National Gas Engine Co. Ltd.*




Two-cylinder Engine and Four-cylinder Vertical — The Campbell Gas Engine Co. Ltd.

which the engine is required to operate above sea level.

There is one point common to all gas engine makers, which might be referred to here, as its advantages and conveniences do not appear to be generally understood. We refer to the compressed air as a starting medium for large gas engines, or even moderate sized engines. The method adopted has become standardised and consists of a small air compressor for belt driving from the line shaft, or a self-contained unit with some form of prime mover. The only other item of importance is the tank or receiver for holding the air under pressure, with its connecting pipes and valves.

The compressed air is used to start up the engine in exactly the same way as steam is used to start up the steam engine. It is usually necessary to operate the barring gear of the engine in order that the piston may be brought into a suitable position for starting purposes. With a single cylinder engine the operation of starting is generally carried out by hand by means of opening and closing the stop valve when at the same time the operator watches the position of the crank, but with the multi-cylinder engine the operation is generally automatic by means of mechanically operated valves on the cylinders.

Returning now to the consideration of some of the leading British makers of gas engines, we will deal first with the Campbell horizontal multi-cylinder gas engine. This is a type which has become very popular in recent years and which has been adopted by most leading British firms.

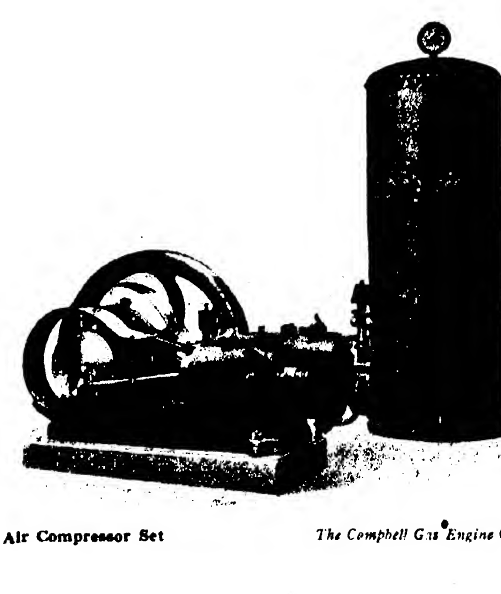
Messrs. Campbell's experience shows that a multi-cylinder engine is preferable to a single cylinder for outputs of about 150 b.h.p. and upwards, and that it is often selected for powers down to about 100 b.h.p. This firm build the horizontal multi-cylinder type with either two or four cylinders. They build the two cylinder type in sizes from 100 to 260 b.h.p., these figures referring to the working load, and the four cylinder type in sizes from 200 b.h.p., up to 520 b.h.p. (working load).

In passing we might mention here that this particular firm have also built the multi-cylinder engine in Tandem form, and although this makes a very sound engineering job, it has not become very popular, and we should imagine that the high production cost by comparison with the side by side type is responsible for this.

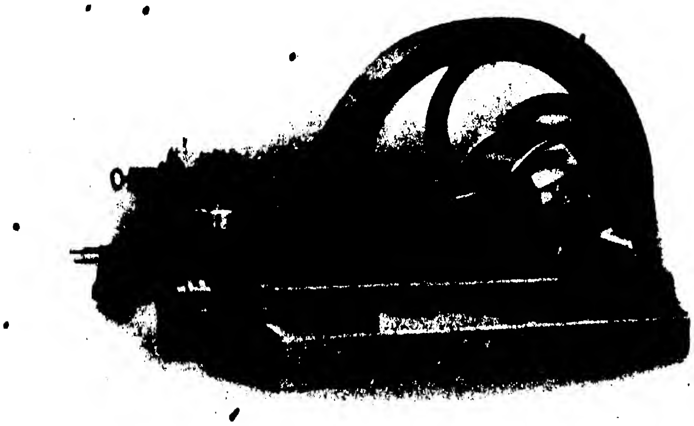
The governing of the Campbell engine is arranged to work on what is known as the "quality" system, that is to say, that only the strength or quality of the mixture is varied, and the same total volume of mixture enters the cylinder at each stroke, thus keeping the compression constant. This is an important point because the compression being kept constant is more favourable to the even working of the engine, and also it is more favourable from a fuel economy point of view.

The figures given for the consumption for this type of engine vary from .75 to .85 lb. of anthracite per b.h.p. per hour, and the consumption for coke is about 25 per cent. greater, and of charcoal about 30 per cent. greater.

Very careful consideration has been given to the question of lubrication on this engine, and cylinders, pistons, exhaust valves and gudgeon pins are supplied from a positively operated pump lubricator with sight feeds. Each feed can be adjusted separately to pass any quantity, small or large, with great regularity and may also be operated by hand if necessary to give an extra flush of



Air Compressor Set — The Campbell Gas Engine Co. Ltd.



The National Gas Engine Co. Ltd.

oil. The large end connecting rod and crankshaft bearings have sight feed gravity lubricators, adjustable separately, the reservoir being continuously supplied by a valveless pump submerged in an oil tank.

The Campbell Gas Engine Co. were among the first British makers to build the large vertical gas engine, and as this firm point out, their first large vertical gas engine was one of 350 b.h.p. delivered in January, 1904, and since this date the purchasers have ordered four other engines—a fact which speaks for itself regarding the Campbell production.

The general construction of the engine will be clear from the illustration; and it is interesting to note that the single acting cylinders are arranged des-axially, that is, with the centre line not vertical over the axis of the crank shaft. This reduces the angularity of the connecting rod on the power stroke and is claimed to diminish the pressure on the cylinder walls by about 20 per cent., with, of course, a corresponding reduction in wear of the piston and cylinder.

The fuel consumption on the multi-cylinder vertical engine is given as varying from .75 to .9 lb. of anthracite per b.h.p., per hour; and as in the case of the horizontal type, when coke is used as fuel the consumption is about 25 per cent. greater, and with charcoal about 30 per cent. greater.

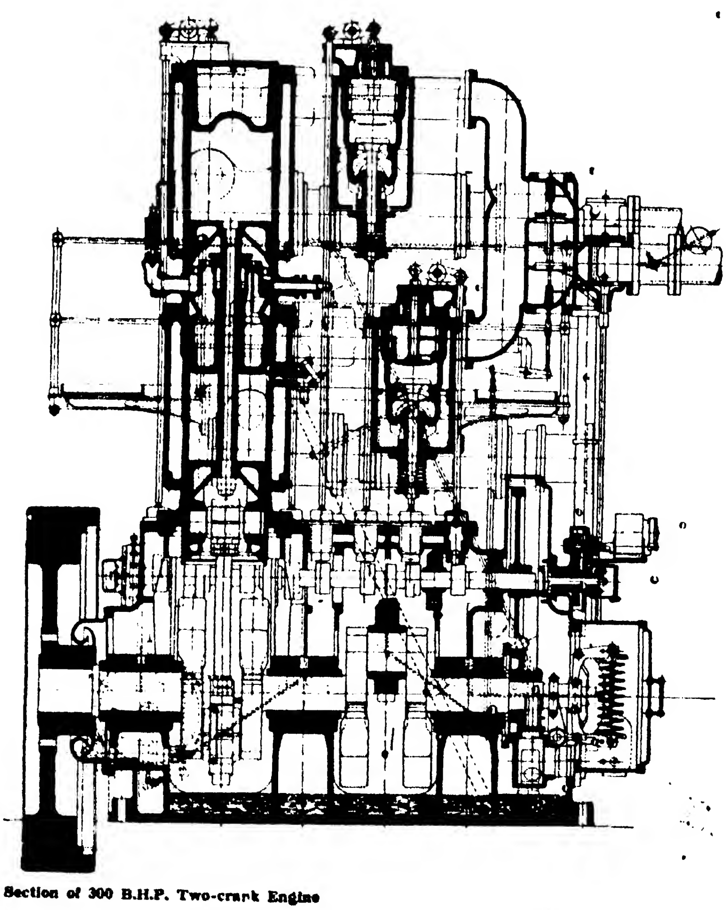
In engines of 520 and 585 maximum b.h.p., this firm include crossheads and slipper guides, the piston rods being of high grade steel ground true and having a flanged attachment to the piston and crosshead.

Another point of interest in the Campbell design is that in engines of 290 b.h.p. and upwards, the exhaust valve is water cooled.

Ignition is by low tension magneto, each cylinder having a separate magneto, and Messrs. Campbell have found that this method in their experience has given extremely reliable results.

The illustration of the horizontal type engine as made by the National Gas Engine Co. Ltd. shows very clearly the general construction of this firm's horizontal type and it will be noted that the arrangement of valves differs from that which is generally adopted by leading British firms. The National Gas Engine Co. Ltd. still adopt a separate valve box on the back of the cylinder and claim that the simplicity and accessibility of this design warrants them sticking to it.

The governing of the National engine is on the "hit and miss" principle in all engines up to 50 b.h.p., but throttle governing can be fitted if desired, this being of course, a special arrangement. In engines from their "XA" type, which develops 75 maximum b.h.p. on producer gas, and in sizes larger than this, the firm



Section of 300 B.H.P. Two-crank Engine

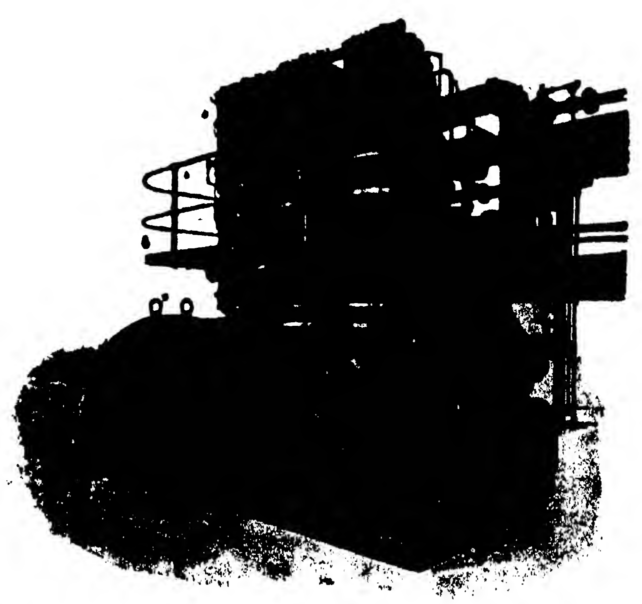
supply their patent variable-admission governing gear, which graduates the impulses to suit the load, the principle being a combination of the quality and quantity system.

The vertical type of gas engine made by the National Gas Engine Co., is a type by itelf, its principal feature being that the cylinders are arranged in tandem form with special stuffing boxes between the upper and lower piston.

The sectional view shows the general construction of this type, and the engine itself is built in standard sizes from 300 to 2,000 b.h.p., with with 2, 3, 4, or 6 cranks.

The engine operates on the four-stroke principle and the space formed between the top piston and the intermediate cover is used as the buffer cylinder in which compression of the air takes place on every down stroke, and expansion on the up stroke, which enables the moving parts to be effectively cushioned.

The governing of the engine is by means of a throttle valve con-



450 B.H.P. Vertical Tandem Engine — *The National Gas Engine Co. Ltd.*

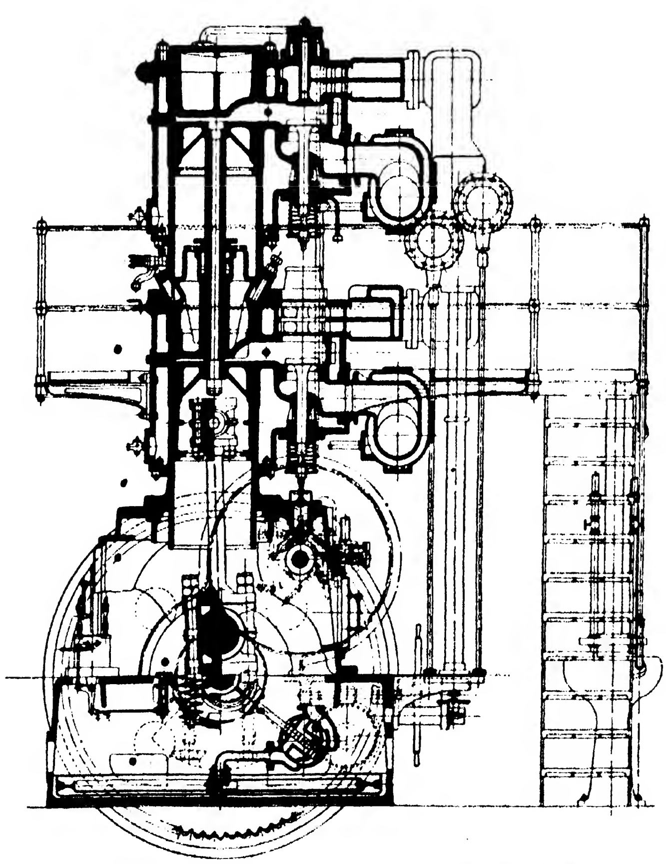
trolled by a centrifugal governor, the throttle operating both gas and air, thus working on the " quantity " principle. This method can, if desired, be arranged to change the mixture with a variation of load, that is to say, to operate partly on the " quality" and partly on the " quantity " method.

Ignition is in duplicate, that is to say, there are two independent sparking plugs in each cylinder, and two or four low tension magnetos and coils in conjunction with which batteries can also be used. The magnetos are driven from the cam-shaft through spur gears.

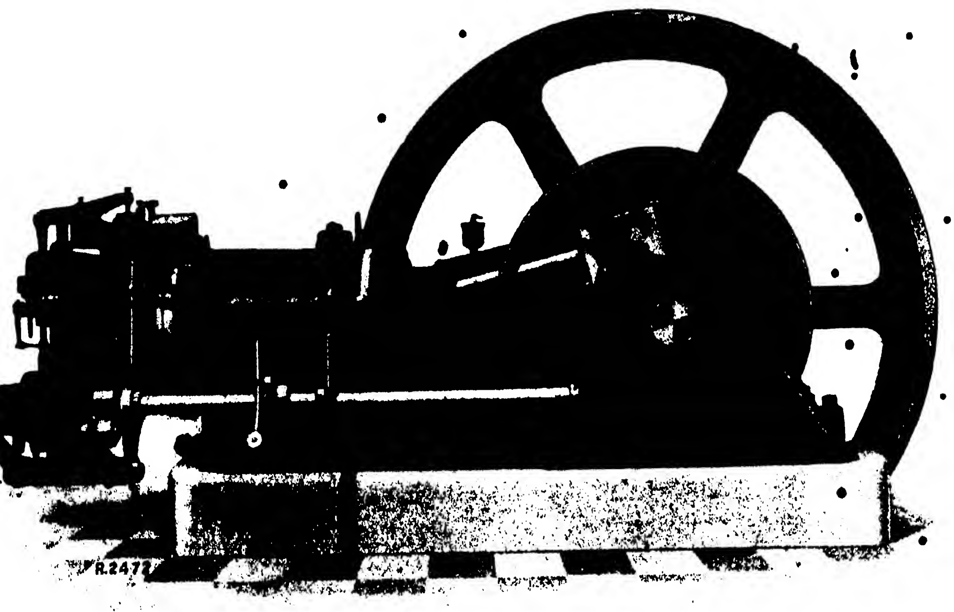
The timing of the magnetos can be adjusted to suit each cylinder independently, or all the cylinders simultaneously, whilst the engine is running, if desired. The ignition current is brought to the sparking plugs through rubber covered cables encased in tinned brass tubes so as to protect them from damage.

For lubricating the working parts, all bearings, pins, etc., are supplied with oil under a pressure of 5 to 15 lb. per square inch, the pressure being obtained by means of a valve-less pump driven from the crank-shaft. All oil is returned to the bedplate from which it is drawn through suitable oil strainers back again to the pump.

The illustration of the Hornsby-Stockport gas engine shows sectional views through some of the principal working parts, and make the con



The National Gas Engine Co. Ltd.



Horizontal Engine — *Ruston & Hornsby Ltd.*

struction of this engine very clear. It will be noted that the valves open direct into the cylinder itself which conforms to the practice of most British firms to-day.

Lubrication for the piston on sizes of 28 b.h.p., and upwards is carried out under pressure by means of a suitable force pump, and the main crankshaft and side shaft by means of suitable ring oilers.

For governing, this firm supply two distinct types. One on the "hit and miss" principle on engines of a less power than 28 b.h.p., and on the 28 h.p. engines and upwards, the firm's "variable admission" gear is fitted, which acts on the principle of varying the amount of gas and air admitted to the cylinder, but in no case cutting off the charge altogether. Both the quality and the quantity of the mixture are therefore regulated, the quality by reducing the amount proportionately to the work, and the quantity by reducing the amount of air to the best proportion to give complete combustion of the gas admitted.

In the illustration "A" is a quadrant operating the valves through the link "C" which is oscillated by the governor in accordance with the load. This regulates the amount of gas admitted by varying the opening of the gas valve by the link "B" and the air is at the same time automatically regulated to suit by the amount of opening of the charge valve which is actuated by the link "C".

Ignition is by low-tension magneto and the sparking plug may be advanced or retarded while the engine is working if necessary.

Utilising Waste Heat

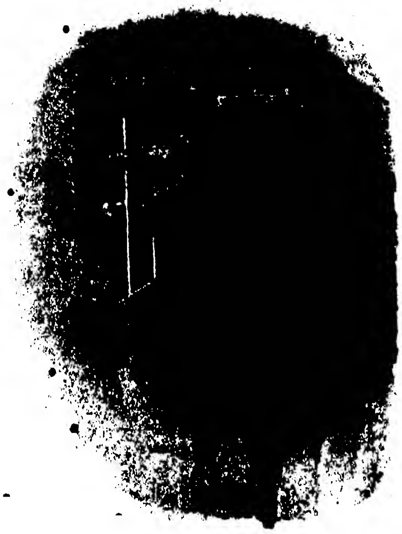
Users of gas engines do not as yet appear to generally understand the economy to be effected by making use of the waste heat from the gas engine, that is to say, by utilising the heat in the exhaust, and also the heat from the water jacket.

In a paper read before the Association of Engineers-in-Charge, Major W. Gregson points out that it is a well-known fact that even in the case of modern internal-combustion engines approximately 40 per cent. of the total heat units in the fuel is lost through the exhaust pipe. On an engine taking 9,000 B.Th.U. per b.h.p. per hour the heat appearing as useful work is just over 28 per cent., and the remaining 32 per cent. on the heat balance-sheet is lost in the cylinder cooling water, as radiation and as engine friction.

Speaking generally, the type of boiler adopted for waste-heat recovery on gas engines is the multi-tubular type; its general lay-out is simple, as it consists, in the main, of a shell traversed by a nest of tubes with a chamber added at each end. The hot gases enter the boiler at one end, pass through the tubes, and are released to atmosphere from the other end of the boiler.

Assuming an inlet temperature to the boiler of 480 deg. C., at full load, and outlet temperature of 200 deg. C., this would give a tube efficiency on the boiler of 58½ per cent., which means that 2,100 B.Th.U. can be recovered as steam, *i.e.*, 2.17 lb. of steam per hour from and at 212 deg. F., and this latter figure is reached in practice by most of the waste-heat boilers at present running.

Regarding the actual use of steam recovered from waste-heat from internal-combustion engines, probably the most common channel in which this is directed is to blow producers; another favourite outlet for this steam is for works or factory heating and in chemical works for industrial purposes. Owing to the comparatively low efficiency of small steam-driven units, it would not appear to be a commercial proposition to convert this steam into further power on small installations, but in the case of central works' power stations containing a number of internal-combustion en-



Combustion Chamber — *Ruston & Hornsby Ltd.*

Governing Gear — *Ruston & Hornsby Ltd.*

gines, it is of course a good proposition to run an auxiliary generating set on the steam available from a battery of waste-heat boilers.

An interesting example of actual results in a particular case, is recorded in the issue of the *Gas Engineer* for September 15th, of last year. We take the following extract :—

"As a fair amount of hot water is required at the works of the Pavlova Leather Company in connection with the various processes in the manufacture of leather, and also in supplying feed water to two Lancashire boilers (28 ft. by 7 ft.) full advantage is taken of the hot circulating water after it has passed through the engine (gas engine), which has previously been softened down to six degrees of hardness. The water, which leaves the engine at about 160 deg. F., is pumped to the hot-water tank which supplies the works, a constant supply of 2,000 gallons per hour being available from this source. For a ten hour day this amount of water at the temperature stated is equivalent to 12 cwt. of coal, although considerably more than this amount of coal would be required to heat the water.

"Another feature in connection with this installation is the use of the exhaust gases for supplying heat for wool drying purposes. This process is carried out in a long brick-built chamber through which passes a wire woven conveyor carrying the wool. During the passage through the chamber it is dried by hot air, which is circulated through the wool by fans driving the hot air through radiators heated by the exhaust gases. The actual heat used in the wool drying chamber is equal to approximately 10 cwt. of coal, though if steam were used for such an arrangement, and allowing for a very efficient boiler, 16 cwt. of coal per day would be required. For comparision purposes it may be stated that a duplicate wool dryer (steam heated) absorbed 1,000 lb. of steam per hour, 80 lb. pressure when tested.

"It will be noted that by using the hot circulating water and exhaust gases from the engine, which, unfortunately, in most installations are not utilised, the satisfactory saving of 22 cwt. of coal per day is achieved. In addition to this, account should be taken of the boiler labour, which is dispensed with under the existing arrangement. When the works extensions are fully completed and the engine is called upon to carry its rated load, on the basis of results now obtainable, the following fuel consumption will be obtained :—

	cwt.
Anthracite consumption per day ...	58
Hot circulating water, equivalent to 14 cwt. of anthracite, exhaust gases equivalent to 14 cwt. of anthracite...	28
Anthracite consumption per day for power purposes	30

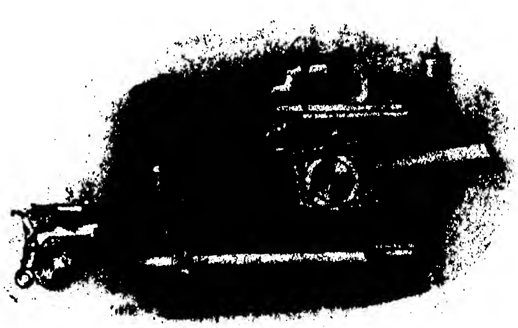
$$\frac{30 \times 112}{600 \times 12} = 0.46 \text{ lb. per b.h.p. hour.}$$

The consumption figures stated are for running time only, and no allowance has been made for standby loss, which averages one to two per cent. of rated capacity of producer plant."

Water Coolers

In conclusion we would briefly refer to the "Heenan" type of water cooler which is of special interest to users of internal combustion engines in a hot climate like India.

This cooler is of the stationary type, the outer casing of which is rectangular in shape, and built up of stout mild steel plates, stiffened where necessary with angles. The base of this casing forms a tank into which the cooled liquid (oil or water,



Piston Lubrication — *Ruston & Hornsby Ltd.*

whichever the case may be) drains, previous to re-circulation. The cooling effect is obtained by evenly distributing the heated liquid over a number of screens set up one above the other in the body of the cooler.

The liquid to be cooled after passing through a strainer enters at the top of the cooler and falls on to the screens, coming into contact with a current of cold air forced upward through the screens by means of a centrifugal fan, the discharge from which is introduced to the underside of the lowest screen. The screens are formed of metallic wool of standard size and thickness, held together between wire netting, the frames being formed of angle steel.

The fan runner is keyed to a shaft which passes through the upper part of the cooler, a pulley being mounted on the opposite end of the shaft to which the drive can be conveyed by means of a belt from countershafting, or from an electric motor direct coupled to the circulating pump. The fan and casing form an integral part of the cooler.

The circulation is maintained by a small centrifugal pump mounted alongside the cooler. This can be arranged for belt drive from fan shaft, or alternatively direct coupled to an electric motor, in which case the drive to the fan would be conveyed by means of a belt from a pulley fitted to the opposite end of the armature shaft. The metallic wool screens are quite accessible and easily removed for cleaning or inspection purposes, but experience shows that this is seldom necessary.

In the upper part of the cooler casing is fixed a number of eliminators, consisting of steel blades, suitably curved. These are designed to arrest the diffusion of loose particles created by the discharge of the heated air from the top of the cooler.

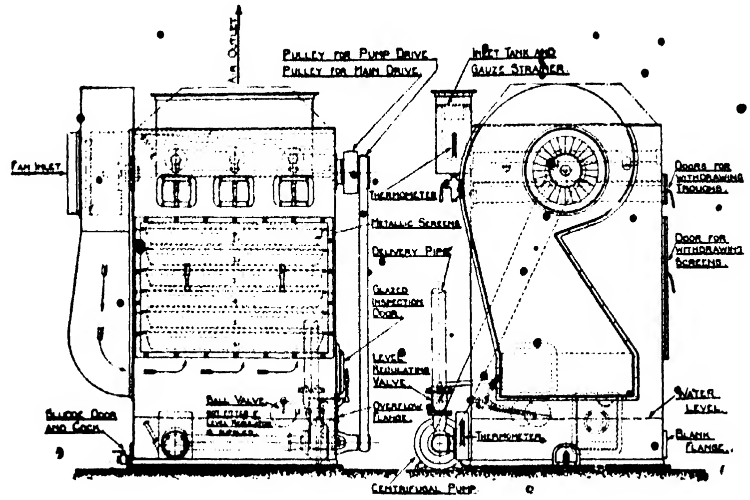


Diagram of Cooler — *Heenan & Froude Ltd.*

Exterior of Cooler — *Heenan & Froude Ltd.*

BRITAIN'S MOST POWERFUL LIFEBOAT

Nearly twenty years ago the Royal National Lifeboat Institution of Great Britain began to install oil driven motors on its lifeboats. The designs first adopted were more or less standard, but of late years the Institution has directed its attention to developing a type which would be wholly suited to the strenuous conditions of lifeboat service. The latest production is a ninety horse power engine which is far and away the most powerful on any lifeboat on British coasts and probably in the whole world. This engine has been specially designed in almost every detail, and each section of it has been made by a British factory specially noted for its supremacy in that particular direction. So long as air is supplied to the engine it will continue to run even though totally submerged. When running at full speed it drives the ship at 8.4 knots and it consumes 8½ gallons of petrol per hour. Since the engine was placed in the boat voyages totalling twelve hundred miles have been run in all sorts of weather conditions without the slightest trouble of any kind being encountered. The Institution has now thirty-eight motor lifeboats at work on the coasts of Great Britain.

TRANSPORT

Conducted by "M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH THE MANAGEMENT AND CONTROL OF RAILWAYS

Carrying the Waters of the Nile into Palestine

The following very interesting description of a War-period Water Supply is taken from the "Sportsman," published by Vickers Petters Sports Club, by kind permission of the Editor, and to whom we are also indebted for the loan of blocks.

THAT Petters Ltd. contributed in no small way to the success of the military operations in Egypt and Palestine, during the Great War, is shown in the short descriptive article by one of our correspondents who saw active service both in Egypt and Syria, and who was employed on the work of water supply.

The great vital problem which had to be solved, and which engaged the attention of a large number of expert engineers, was the provision of an adequate water supply for the needs of the railway to Palestine and the troops engaged in operations under the direction of Field-Marshal Allenby and General Murray.

After numerous reports had been called for and received by the Commander-in-Chief, as to the total quantity of water available, it was eventually decided that, as there was not a sufficient supply in the locality for the large number of troops which the authorities intended to use, the water brought down by the Nile through the Sweet Water Canal, running parallel to the Suez Canal (Fig. 1), should be utilised as far as possible by means of a pipe line constructed alongside the railway across the desert.

As the Army advanced into enemy country, so followed the railway and pipe line in its footsteps, daily building up and strengthening the line of communication with Egypt against enemy attacks.

The Sinai Peninsula consists for the greater part entirely of arid sandy and waterless desert where nothing grows except a few low bushes and coarse grass. The monotonous stretches of country are only relieved at long intervals by oases where water may be found in small quantities. The first oasis reached from Kantara, the base of the Army, is at Romani, which consists of a few date palms, some shallow wells from which the Bedouin population draws its water, and a mud shelter or two, in case of a sandstorm, which frequently occurs.

The country then becomes very flat, extensive salt marshes occurring, impassable in winter, and in summer consisting of hard salt and gypsum, due to the evaporation of the surface water. Water can almost invariably be found by digging in the sand along the seashore, but it is of very poor quality, always brackish, and was found to be quite unsuitable for the requirements of the troops in occupation of the country.

The wells of Katia, Bir el Abd and Mazar furnish a small supply for the wandering Bedouin of the district, and at the two last-named places pumping stations were erected to deal with the water supply brought through the pipe line from Kantara. The first town of any importance reached from the Canal is El Arish, which is of historical interest. . . . drove the Turk . . . om his

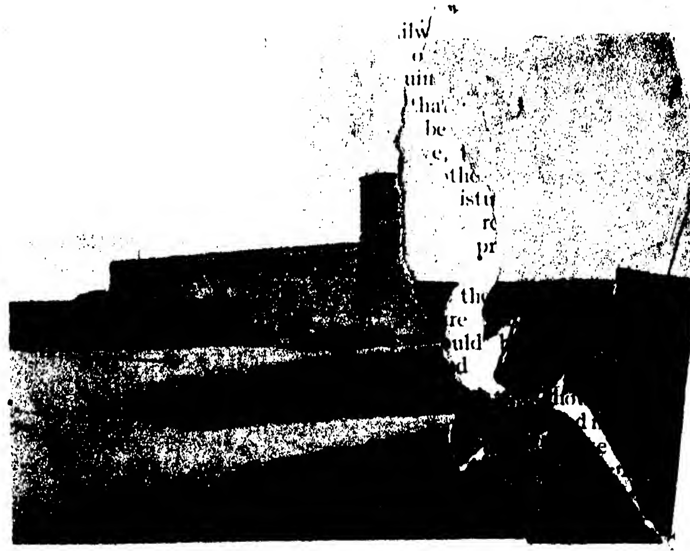
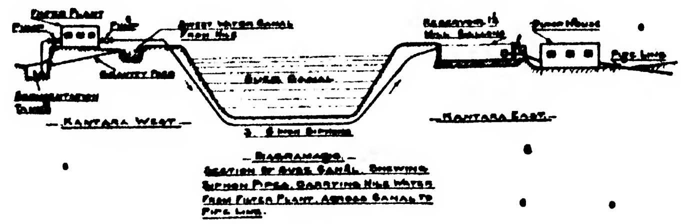


Fig. 6

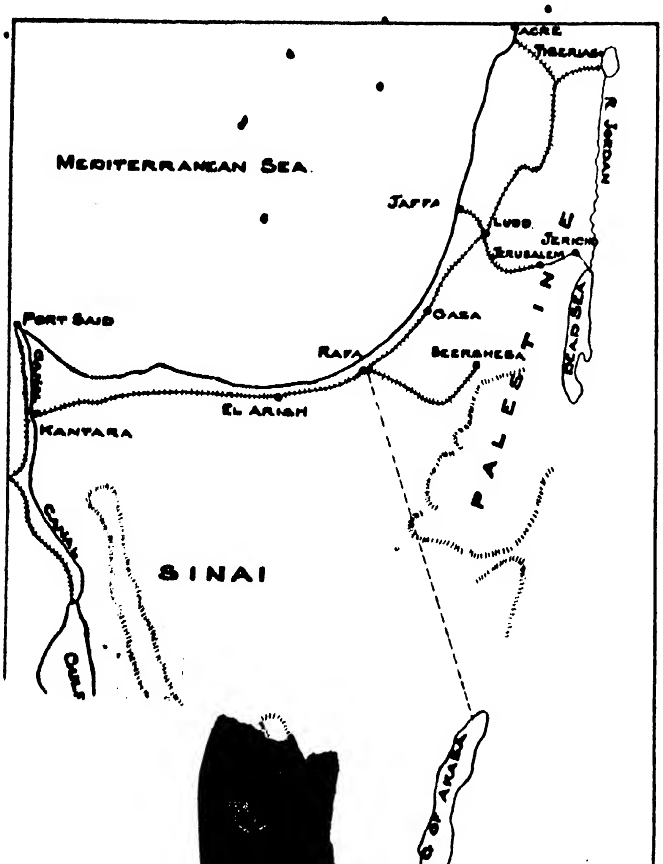
The town lies on a hill fronting the sea at the foot of a large quadrangular castle, which is approached by means of a great gate on either side of which is a round tower with marble pillars. It was built by the Sultan Suleiman 500 years ago.

The population numbers about 2,000, all of whom are engaged in agriculture. Dates, grapes, figs, melons, and all kinds of vegetables



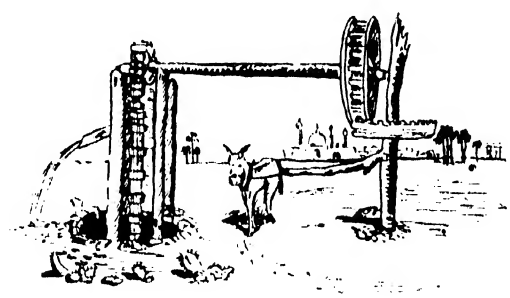
Diagrammatic Section of Suez Canal, Shewing Syphon Pipes, Carrying Nile Water from Filter Plant, Across Canal to Pipe Line.

Fig. 1



...n as ...own, ...oops, ...ne of ...y and ...heir en- ...s in fresh ...h were a ...v beef and

...to Rafa ...ne old Turco- ...n, the country ...ous sand dunes th the sea, and ...impossible for any distance. Camel transport was found to be the only reliable means of travel in this district until the railway arrived. Twenty miles distant lies the village of Khun Yunis, the first view of the Promised Land. Here there is an old castle built in the days of the Crusades, when Richard Coeur de Lion came over against the



Old Saggia at Work at Beersheba

Fig. 3

Saracens, who occupied the country. Here also, as at El Arish, there is a market, mosque and school, which are all collected round the castle. The gardens are well watered and very productive.

The two principal wells which were left by the Turks were taken over by the Army, and Petter oil engines and

Plan of Pipe Line Kantara to Rafa — Shewing Engines & Pumps Used at the Respective Pumping Stations.

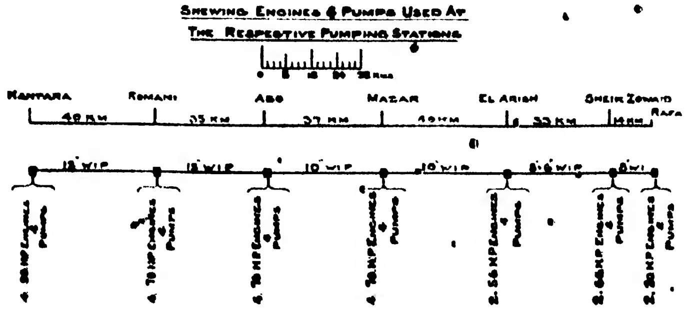


Fig. 4

Fig. 5

pumps erected, reservoirs built, and a water supply of 100,000 gallons a day obtained. One of these wells was found to be constructed entirely of marble. Charges of dynamite were discovered inserted in the well lining, and it was evident that the Turks had originally intended to demolish the well on their retreat.

The Construction of the Pipe Line

The installation of plant that the authorities decided upon was capable of providing, at the outset of the campaign, 500,000 gallons of water per diem. This necessitated the provision of duplicate 60 h.p. engines with pumps at Kantara, Romani, Abd, Mazar, El Arish and Shiek Zowaid, with 20 h.p. engines and pumps at Rafa, the Palestine Border. The accompanying sketch (Fig. 4) shows a plan of the pipe line and pumping stations distributed across the 100 miles of desert.

Seventy miles of 12-in. W.I. piping and 40 miles of 10-in. W.I. piping, with the necessary engines, pumps and machinery, were supplied from England, India and America, ships being especially escorted through the Mediterranean by the Navy. Over 12,000 tons weight of plant was handled at Kantara, where it was unloaded on to wharves built for the purpose.

The transport work on the different sections of the pipe line was carried out by the railway (broad gauge) which was being constructed rapidly across the desert. Pipes were unloaded from the rail wagons, on to Holt tractors, which conveyed them to their site of erection, where they were fixed in position by native labour under direction of R.E. officers and men especially appointed for the work. Considerable difficulty was experienced at first in training the Egyptian labour, which was recruited from the Nile Valley, in the handling of the tools for screwing the large diameter pipes. Progress was slow at first, but by degrees, as more skilled labour was brought on to the work, and by paying the gangs on piece-work basis, the rate of coupling up increased considerably. As many as forty 12-in. pipes could be laid in a day by a gang of one European foreman and twenty-five native labourers. (See Fig. 8.)

Expansion joints were put in at every two miles, to counteract the expansion and contraction of the steel pipes while no water was in them as they lay exposed to the hot sun. Gangs of natives were employed to follow up the screwing parties in covering up the pipes with sand, and so protect them as far as possible from sudden changes of temperature of the air.

While the pipe line was being laid down, filter plants, reservoirs and pumping stations were being built and erected at the places shown on Fig. 2, so that as soon as one section was completed, water could be supplied immediately, and the supply used for the section immediately in front of it.

The pipe line was completed as far as El Arish in 125 days, 155 kilometres from Kantara, and worked without interruption except for a few hours when it was put out of action by an enemy aviator, who came down and blew in a few lengths of pipe, which were quickly replaced. Engine houses and reservoirs were well sandbagged and protected from enemy attacks in many places, and engines were duplicated in separate houses. No serious damage occurred at any of the stations.

In 1918 the pipe line from El Arish was further extended into Palestine to Ragafa, and supplied filtered Nile water through a distance over 150 miles to the troops during operations which drove the Turk from his

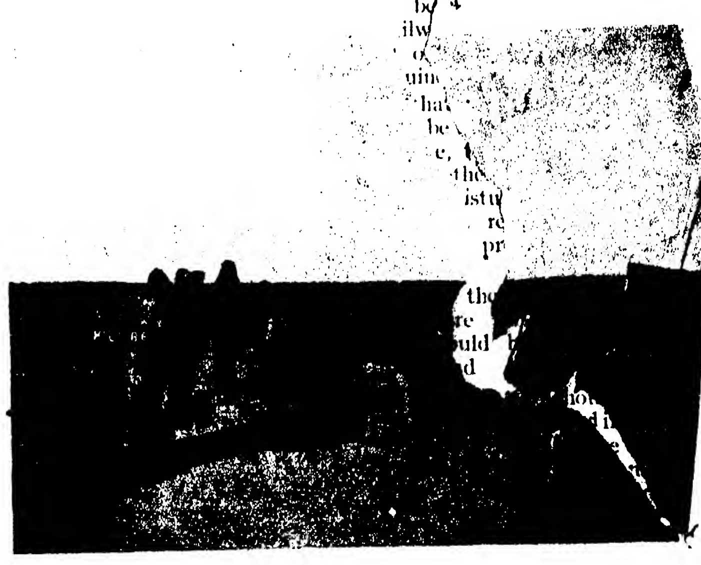


Fig. 8

FIG. 7

position round the towns of Beersheba and Gaza.

Rafa. Notes on Advance

Rafa, which is 40 miles from El Arish, formed the culminating point of the pipe line from Kantara, and it was here that Field-Marshal Allenby established his head-quarters in 1918, when active operations against the Turks commenced in the latter part of the year. His immediate objective was the town of Beersheba, which was occupied by a large Turkish force under German command. As the local water supply was insufficient for the needs of the troops in this area, which was held by the Twentieth Army Corps, a branch pipe line was projected from Rafa, through [illegible] 6-in. pipe, delivering 5,000 gallons of water per hour to Shellal, where a small local supply was obtained in the [illegible] river bed. Here three sets of [illegible]5 h.p. engines and pumps (centrifugal) were erected, and the water supply carried on towards the enemy's front in conjunction with the railway.

Advance on Beer[illegible]heba

As soon as it was found that adequate provision had been [illegible] made for the water supply of the [illegible]s, orders were given by Allenby [illegible] an advance to be made on the town of Beersheba, which was known to contain an abundant supply of water. The enemy was met at midnight, November 30th, and after a stubborn resistance, evacuated the town, which was entered next day by the Australian Mounted Brigade.

In the meantime, on the West, Gaza was being heavily bombarded both from the land and sea, and it was here that our troops inflicted heavy losses on the enemy, who evacuated and retreated into the hills, leaving thousands of prisoners in our hands. (For the operations against Beersheba, thirty-three pumps and engines were erected, having an aggregate of 290 h.p.) After the capture of Beersheba and Gaza, the pipe line water supply was not required to such a large extent as previously. Local supplies from wells and rivers were developed, and many engines and pumps which had supplied water through the pipe line were moved to other localities, where they were needed in developing the wells already existing to supply the troops in their preparation for further operations against the enemy.

The accompanying sketch (Fig. 3) shows how the water was raised from the well by means of a donkey working a chain of wooden buckets, called a saggia. This well was one of several found in Beersheba left by the Turks. A pump was installed and a Petter's engine erected, increasing the supply by nearly 10,000 gallons daily.

EVAPORATION LOSSES IN THE OIL INDUSTRY

The enormous loss in the (petroleum) oil industry caused by evaporation in working and handling has been dealt with in a comprehensive manner in a recent publication of the United States Bureau of Mines, embodying the results of 140 tests carried out under actual practical conditions, supplemented by much laboratory work. It is estimated, as a result of these careful investigations, that in the "mid-continental" oil fields of the United States alone, actually over 500,000,000 gallons of petrol are lost per annum, say about 1¼ times the actual output of petroleum of the whole of the United States.

It appears that from the oil well to the refinery about 6 per cent. of the oil obtained is lost by evaporation, in addition, of course, to the huge amount of natural gas and very low boiling point fractions which are wasted when the oil well is tapped. One of the chief causes of the loss during handling is in the so-called "dehydration" process. Most crude petroleum contains about 2 per cent. of water intimately mixed with the oil, and this is caused to separate from the oil on standing by treating the crude oil with very hot water in tanks. This process seems to be generally carried out on the most elementary lines, and there is a very serious loss of low volatile compounds, amounting in some cases to as much as 2½ per cent. of the crude oil. Another cause of loss stated in the report is the needless amount of handling of the dehydrated oil in storage, which seems to be moved about from one store tank to another many times, and is often in these various tanks four to six months. The capacity of such tanks is usually 55,000 barrels (38 gallons each), and in one particular investigation it was found that 1,440,235 barrels of oil stored in thirty different tanks had lost in one year 2.23 per cent. of the volume, or 32,100 barrels of petrol. Further losses are incurred to the extent of 0.30 per cent. in the filling of railway tank cars from the pipe line, 0.5 per cent. in emptying these tank wagons again at the end of the journey, together with a further 0.5 per cent. leakage *en route*. The United States Bureau of Mines are of the opinion that by the adoption of very simple methods, nearly the whole of this enormous loss could be prevented. In a hot country like India, the evaporation in connection with the handling of petrol and similar products would seem to be even worse, but these American investigations show that it is not so much the temperature of the air that causes evaporation as the air currents, and it is in this direction that the greatest precautions are necessary.

Indian Railways in 1921-22

Unfavourable trade conditions in India during the past year militated against satisfactory results. The fact however, that total earnings rose from Rs. 91.98 Crores in 1920-21 to Rs. 92.88 Crores is a distinctly favourable sign of development possibilities under more favourable conditions. On the other hand, there was a considerable increase in the working expenses. The Administration Report for the last financial year is of great interest, and is briefly reviewed in the following article.

IN my review of the Administration Report on the working of the Indian Railways during the year 1920-21, I commented favourably upon the improved form of Report that had been adopted, and especially remarked upon the exceeding utility of the information published for the first time in that manner. It is pleasing to note that the Report for the past financial year is, if anything, an improvement on that to which reference has been made, and it is my purpose, after briefly reviewing the main features of the report in this article, to contribute a special article to next month's issue of INDUSTRIAL INDIA outlining the extent of the developments now being effected on the Indian Railways, and discussing some of the problems that are now by way of being solved.

Moreover, it is worthy of note that the Administration has now definitely accepted the need for more detailed information on the railway position, and in the Preface to the Report, it is stated that a new feature has been specially introduced to meet the circumstances of the present. While the scope of previous reports has been confined to the year under review, developments in India, especially in connection with the recommendations of the Railway Finance Committee, have been followed by considerable criticism, frequently uninformed, and as it is recognised that the public attitude in this matter has been due to want of information, an effort to meet this need has been made in the report under review.

Railway Finances

Chapter I begins with the very true remark that "financial considerations have assumed a position of very special importance in relation to railway development and working." It is for this reason, and because, also, the subject was dealt with so exhaustively by the Acworth Committee, that the Administration have treated this question first in their report.

The total capital expenditure incurred on the construction of all railways in India up to the end of March, 1922 amounted to Rs. 656.06 Crores, the capital outlay during the year being Rs. 25.78 Crores. Of this sum, Rs. 2.11 Crores was spent on new lines, and Rs. 21.32 on open lines account, Rs. 10.04 on rolling stock and Rs. 11.28 on works, including stores. On both these open lines items the expenditure was less than during the previous year, this being due, says the report, not to any slackening of effort, but to the fact that the grant alloted was Rs. 23 Crores against Rs. 25½ Crores in the previous year. In a word, the coat had to be cut according to the cloth, and it is no exaggeration of the position to say that if this altogether inadequate method of providing for betterments, coupled with the ridiculous lapsing system, had been retained, there was very little hope for real improvements. Happily, this antiquated practice has now been discontinued, and while there is no need to recapitulate what I have already written with regard to the deliberations of the Acworth Committee and the consequent establishment of a Railway Finance Committee to review its recommendations, it is of importance in this review to indicate precisely on what basis future arrangements are to be made.

Railway Finance Committee's Recommendations

The Railway Finance Committee was greatly impressed with the evidence given before the Acworth Committee in regard to the need of rehabilitation and improvement of the existing lines, and it was considered that for this purpose a guaranteed programme extending over a course of years was almost as important as the possession of larger funds. They accordingly recommended :—

(*a*) That the programme should be prepared on a five years' basis, the provision for each quinquennial period being considered about two years before the termination of the existing period ;

(*b*) that there should be *no lapse of money voted* for any one year but not spent within that year, such sums being carried on to the credit of railway administrations up to the limit of the total amount fixed for the quinquennium ;

(*c*) that the finance programme should be strictly adhered to, subject, of course, to the understanding that a war or other unforeseen contingency radically disturbing the money markets might render it necessary to curtail the programme in any one year ;

(*d*) that the programme for capital expenditure during the next five years should be fixed at Rs. 150 Crores ; and

(*e*) that this sum should be devoted to the rehabilitation and improvement of existing lines and to the completion of lines already under construction.

The Legislative Assembly duly confirmed the Committee's proposals with regard to the five years' programme, and as they were also accepted by the Government of India

and the Secretary of State, they now form the basis of future railway capital finance. As the Report well says, "it is impossible to over-rate the importance of this decision as affecting railway development in India." For the first time the railway adminstrations are in a position to plan ahead and to carry out their schemes of improvement with a full assurance of financial support. Truly a charter of wonderful potentialities, and one that will be reflected in the more effective working of Indian Railways when the improvement schemes have been brought to fruition and have exercised their beneficial influence on railway working.

The Establishment of a Depreciation Fund

A further satisfactory development is that provision is to be made in future for the renewal of worn out plant by the building up of a Depreciation Fund. This is a measure adopted by all commercial concerns and is one of ordinary prudent management. Steps are being taken to fix a suitable basis for the various items, and, subsequently, annual sums will be earmarked for renewals and replacements. The Report, commenting upon this phase of the financial arrangements, states that "stability in respect of the provision for revenue renewals is in its way of almost greater importance than for capital since it is the deterioration of the assets—both rolling stock and track—which is responsible for the present railway troubles. . . . Measures have now been initiated which will, it is expected, provide a solution, and it may confidently be hoped that the Indian Railways are now within measurable distance of surmounting the last great difficulty in their financial arrangements."

As the financial phase of the railway business is, obviously, the main text for this article, it will not be possible to do more than briefly sketch the other matters dealt with in the financial section of the report. It should, however, be clearly laid down, as a commentary upon the difficulties of the position, partially abetted by bad trade and largely caused by railway troubles, that the return on capital for the year 1921-22 was no more than 2.75 per cent., this comparing with 4.74 per cent. the previous year, 6.28 per cent. in 1919-20 and still higher percentages in earlier years. As a matter of fact, when full account is taken of the financial position, the result is that, for the first time since 1900, the railways "have fallen from the status of an important source of revenue to the country and are responsible for the addition of a very heavy amount to the annual liability of the Government." Of course, as the Report very justly observes, these conditions represent nothing more than a temporary phase similar to that apparent in other parts of the world, and I would add to that observation the fact that, as the improvements now being urged forward will undoubtedly ease the traffic position, and enable the railways of India to move a great deal more traffic that was offered, but could not be moved under the old conditions, future years should show very substantial improvement.

In view of the unsatisfactory showing during the last financial year, it is not surprising that the Administration Report, in concluding the financial section, should make reference to the fact that during the last 22 years the net gain to the Government from the working of railways has aggregated nearly 108 crores of rupees after paying all interest charges, and in several cases contributing liberally towards the extinction of capital liability by payment of annuities. "The fact that railways have demonstrated in the past in this very practical manner their capacity to add to the country's revenue should be an ample assurance that the temporary set-back in 1921-22 is not due to any inherent cause, and that the old traditions will be resumed when trade and internal prosperity have fully recovered from the disorganisation which has followed in the wake of the war.

Railway Earnings during the Past Year

It is worth while briefly to consider the causes that led to the earnings of the State-owned railways being less than was expected, and to analyse the general conditions bearing upon railway receipts. While the total earnings for all lines rose from Rs. 91.98 crores in 1920-21 to Rs. 92.88 crores—a fact showing clearly the capacity for development of railway earning power even under unfavourable conditions—the total earnings of the State-owned lines amounted to Rs. 81.87 crores against the sum of Rs. 87 crores anticipated when the budget was framed.

Railway earnings naturally depend largely upon satisfactory trade conditions, and while this is especially true of goods traffic, it also applies in regard to passenger traffic. Thus, when it is noted that features of the import trade for the year 1921-22, as compared with 1920-21, were a heavy decrease in the imports of manufactured goods, especially under cotton manufactures, iron and steel, motor vehicles, paper, woollen piece-goods, and hardware, and an increase in the imports of sugar, wheat and coal, the difficulties of the position will, in a measure, be realised. The check on imports was due principally to higher prices accentuated by high freights and increased customs duties. On the other hand, owing to the good monsoon all over India, there was no lack of commercial crops for export; but this favourable state of affairs was neutralised by the reduction in the purchasing power of the continental countries which for the time being deprived India of her best markets.

So far as the internal position was concerned, the conditions were generally favourable to a prosperous railway year. The production of rice showed an increase of 19 per cent. and cotton 24 per cent. over the preceding season, while sugar cane, sesamum, groundnut and indigo yielded better crops than last year. Jute, however, showed a decrease of 32 per cent., owing to a greatly restricted area having been placed under the crop. While, therefore, the year was by no means unfavourabe for internal trade, the conditions militated against a development of external trade, on which railways depend to a great extent. The result of these conditions is clearly reflected in the figures of tonnage carried and the earnings of the lines leading to the principal ports.

An analysis of the two main sources of railway earnings, goods and passenger traffic, shows that the total rise of nearly a crore is made up of a decrease of half a crore in passenger earnings and an increase of about a crore and a half in goods earnings. There were, however, more passengers carried than in any previous year, while the goods tonnage was not equal to that of the preceding three years.

Railway Expenditure

In view of the fact that, speaking generally, railway working expenses have increased in all parts of the

world, it is not surprising to find that in India there has been an increase of some significance. The percentage of expenses to gross earnings of all railways in 1921-22 was 76.22, this comparing with 65.54 the preceding year, an increase of 10.68 per cent. This is all the more serious when it is considered that the ratio in pre-war days ranged about 52 per cent., and indicates an avenue to be explored with thoroughness in any attempt to improve the railway situation. In India, many lines are worked on a very narrow margin of profit, and it is obvious that the maintenance of such a high ratio of working expenses cannot be viewed with equanimity.

Expenses Distribution

An analysis of the distribution of the expenses on all railways between the various spending departments shows that nearly half the total increase occurred in the Locomotive Department alone, this being due primarily to the high cost of fuel. Altogether, Locomotive Department expenditure in 1921-22 was Rs. 25.42 crores as against Rs. 20.88 the previous year. Engineering expenditure advanced from Rs. 11.95 crores in 1920-21 to Rs. 14.33 last year, and from an analysis of the different classes of expenditure it is apparent that heavy renewals of rails, sleepers and bridges are largely concerned.

On this question of expenditure the Administration Report very closely analyses the various items, and endeavours to show precisely the cause for the increases. This section is extremely well done, and one need have little hesitation in subscribing to the conclusion that, on the result of the analyses, there is good reason to hope that a good deal of the working expenses will gradually disappear as the lines are brought back into normal condition. A final note is made as to the rise in the wages bill, and attention is called to the fact that every railway in India has now, under the Railway Board's instructions, adopted systematic measures (by means of Retrenchment Committees or otherwise) to prepare and carry out a regular campaign of economy in every phase of railway expenditure. Good results are expected from this development.

Indianisation of the Railway Service

Space considerations prevent any further elaboration of the many other interesting features in the Report. In a subsequent article, I shall deal in detail with the new sections which outline the extent and scope of the development work projected and in hand, and from that description shall draw conclusions as to future progress. Meanwhile it will be sufficient to say that the Report contains two instructive sections dealing with Railway Staff and Railway Materials respectively. The latter will be reviewed in my next article, but it may here be added that, as indicated in my survey of the previous year's report, the Indianisation of the railway service is steadily progressing. As compared with 729,789 Indians employed on the railways of India in 1920-21 there were last year 735,789, while the corresponding figures of Europeans and Anglo-Indians showed decreases in the former case of 400 to 6,858 and in the latter case of 100 to 11,831.

In this connection it is important to note that during the Delhi session of 1921-22, the following Resolution was adopted by the Council of State :

> "The council recommends to the Governor General in Council the necessity of taking early steps to increase the number of Indians in the higher grades of service of the State-managed railways, and of devising means to secure the adoption of a similar policy by Companies managing State Railways."

The Government, in accepting this Resolution, explained that they had already accepted the policy of gradually Indianising all the public services, and stated that the policy would be applied to the higher railway establishments wherever possible, subject to making efficiency the paramount consideration in railway matters. Much has already been done in the way of Indianising the superior establishments of State-worked railways, as 25 per cent. of the Engineering officers, 25 per cent. of the Superior Traffic Department and 8 per cent. of the Superior Stores Department are now Indians. So far as the Locomotive and Carriage and Wagon Departments are concerned, it has only been possible to make a small beginning, owing to the lack of facilities for proper training in the country. Extensive schemes for the training of mechanical engineers are, however, now under consideration. The Report, it may incidentally be added, gives a certain amount of space to a description of the training facilities already provided, and intimates that an experienced officer is investigating the whole question of the training of Indians.

I am drawing to the limits of my allotted space, and must at this point leave further review of this able Report to a subsequent article. Let me, however, place on record my belief that in this, the last, Report issued by the Indian Railway Administration, they have really reached down to the problem, and have published a lucid, interesting and comprehensive statement of the Indian railway position. As usual, the Report is in two sections, one of 84 pp. with maps, and the statistical appendix of 237 pp. The latter is of great importance to the keen student of railway affairs, but the former is the document of special interest. Its price is Rs. 3-8, and all those interested at all in Indian Railways would be well advised to purchase a copy. In fact, were I in a position to do so, I would insist upon the Railway Board printing Volume I in pamphlet form, and circulating it broadcast among the users of the railways. It would not only disarm criticism, but would tend to give the man-in-the-street information as to railway difficulties and the manner in which they are being met that could not be otherwise than to the common good. Few Reports are as complete, none more interesting, and when I say that it is equal to, if not better than the yearly reports of the South African Railways and the Japanese Railways, there could be no higher praise.

A final word. There is no need to despair of the future of the Indian Railways. They have large expenditures to face in order to bring their lines and equipment to the required standard, but once this has been done, the traffic development that will assuredly follow should prove abundantly sufficient to show full justification for this course.

SYNTHETIC CHEMISTRY

(*Continued from page 578*)

fate which befell the plantations of madder, and, so far as can be foreseen, they are not likely to suffer great disaster. The reason for this, however, lies outside the control of the chemist, and is to be found in the scarcity and cost of the raw material used in the manufacture. The source of the raw material is oil of turpentine, an essential oil which is produced in trees belonging to the different species of pine, and which is not only restricted in quanity, but is also subject to increase in price. The synthetic camphor, therefore, has not been able to displace the natural, but it has prevented an excessive rise in the price of the compound.

Very different from the dyes, drugs, and other synthetic products just described, is a remarkable material which we owe to the American chemist, L. H. Baekeland, and which has, in recent years, acquired a very great industrial value. On warming together phenol (carbolic acid) and formaldehyde—obtained by the oxidation of methyl alcohol or "wood spirit," and sold, in solution, as a disinfectant under the name of formalin—along with a little ammonia, which hastens the reaction, a thick gummy mass is produced. When freshly prepared, this gummy material can be dissolved in alcohol, acetone, and other similar solvents, but on being heated to a temperature of over 100 deg. C., of 212 deg. F., it changes into a hard, resin-like solid, to which the commercial name of bakelite is given. Bakelite is an infusible material, and insoluble in all solvents; it is not affected by alkalies or acids, and may even be boiled with dilute sulphuric acid without undergoing change. It is an excellent insulator for electricity, and finds, in consequence, perhaps its most important applications in the electrical industries. Bakelite may be employed for a great variety of purposes—as a substitute for amber in pipe-stems; for making billiard balls, the elasticity of bakelite being nearly equal to that of ivory; and for making buttons, knobs, knife-handles, and many other articles for which bone, celluloid, ebonite, or other material is at present employed. It is not so flexible as celluloid, but it is more durable, is not inflammable, and is less expensive. Wood, impregnated with the initial liquid material, and then heated, becomes coated with a hard enamel-like layer, equal to the best Japanese lacquer; and metal articles, similarly, can be covered with a hard and resistant coating.

Engine Indicators

The last meeting of the Institution of Mechanical Engineers was devoted to a symposium on "Indicators," four papers being presented on the subject, dealing particularly with the application to high speed petrol, gas, and oil engines.

Mr. Pendred, in the first paper, gave a survey of the history of the indicator, and dealt particularly with the work of Osborne Reynolds about forty years ago on the inherent inaccuracies of the steam engine indicator, due to inertia, piston friction, the vibration of the spring, and other similar influences. The possibility of errors of say 5 per cent. on all indicators running at over 300 revolutions per minute is of course admitted.

In another paper Mr. Collins described in detail his well-known "Collins" continuous micro-indicator, already mentioned previously in these Notes, in which the instrument—of the cylinder and piston type—gives continuously a tiny series of indicator diagrams on transparent celluloid, which are read with a low power microscope, and is of particular value for indicating very high speed engines of the motor car and aircraft type.

Mr. Wood, of the Government Aircraft Engine Research Section, then described a special electrical indicator of the "balanced" type, as used specially for aircraft engines, of 1,500 revolutions per minute. In this special type of indicator the varying pressure in the cylinders is not recorded directly as usual, but the time is taken when the pressure balances, a known standard pressure, and by gradually increasing this pressure a series of time records is obtained comprising the whole range of pressure in the cylinder, although each pair of records belongs, of course, to a different engine cycle. A complete record can, however, be taken in less than ten seconds. The instrument is very difficult to describe in a few words, but the essential principle consists in the balance point being indicated by the pressure in the cylinder lifting a valve controlled by a known and controlled air pressure, and the motion of this valve breaking an electric circuit causes a spark which perforates a sheet of paper on a rotating drum, a series of such perforations giving the diagram.

The last and most interesting paper was that by Professor F. W. Burstall, who gave a detailed account of his new optical indicator, designed more especially for medium speed high compression gas engines. This indicator is of the piston type, and is designed so as to embody the four essential principles of geometric fittings (so that accuracy does not depend on workmanship), water cooling, efficient lubrication of the piston without taking the indicator to pieces, and metallic bodywork throughout to eliminate possible minor errors due to the splitting of wood. It is also very difficult to describe this ingenious and accurate type of indicator in a few words, but the spring is made of one piece of tool steel, and the working portion is tapered to give it uniform strength, being attached to the top of the piston rod by a ball and socket connection. The piston is slightly barrelled to prevent it sticking, and the area is 0.125 square inch, the total load being 75 lb. at the maximum pressure of 600 lb. per square inch, for which the indicator is designed, the movement of the piston being 0.08 inch. The cock body and plug are water cooled, and the instrument is provided with a hand-operated lubricator. The source of light is a "Pointolite" lamp, the illumination being given by an incandescent metallic ball. The beam of light passes through a special diaphragm formed of two pairs of steel plates with polished edges on to a mirror attached to the end of the indicator spring, and is reflected to a second mirror oscillated by a quadrant arm connected to the engine piston by means of a long light wire and lever. The ray of light, indicating the cycle of movement, is passed on to a photographic plate, the special diaphragm arrangement confining the light ray so that it forms a single and definite pencil of light, giving a clear and sharp record on the photographic plate, which is developed as usual. The subject of indicators is of particular interest, since the Institution of Mechanical Engineers is about to undertake a research on the working of oil engines.

SCIENCE

Conducted by A. H. HAVER, M.I.N.A. & K. S. DICKINSON, F.C.S.

THIS SECTION DEALS WITH THE APPLICATION OF SCIENCE TO INDUSTRY AND PARTICULARLY DEALS WITH APPLIED CHEMISTRY

Synthetic Chemistry

(*Continued from page* 408.)

THE sixteenth and seventeenth centuries are regarded as marking a distinct ere in chemistry, inaugurated by Paracelsus. During that period chemistry was looked upon as the handmaid of medicine, and the study of the action of substances on the human organism, and the preparation of drugs, were held to be the true functions of the chemist. That was the period of what was called iatro-chemistry.

While the modern chemist would resent the restriction of his functions within such narrow limits, the services which chemistry have, in modern times, rendered to medicine are greater beyond comparison than all the iatro-chemists were ever able to perform. Not only have "Nature's remedies," the juices and extracts of plants, the valuable alkaloids like quinine and morphia, been exhaustively studied, and the methods of their extraction improved, but they have been supplemented, in some cases even displaced, by a large array of new drugs and medicinal preparations which owe their origin to the genius and painstaking labours of chemists. The herbalist, in fact, has given place to the scientific chemist, and the manufacture of synthetic drugs, anæsthetics, hypnotics, antipyretics, and drugs for the treatment of special diseases, has developed, in the past thirty years, into an industry of great importance.

The earliest of these synthetic products dates from 1832, when Liebog prepared the anæsthetic, chloroform, by the action of bleaching powder on alcohol. Who will dare to compute the sum of misery and suffering from which this one discovery has freed mankind, or place a money value on the service it has rendered? But the discovery of chloroform has been followed by the discovery of other anæsthetics; general anæsthetics like ether and ethyl chloride (also, like chloroform, produced from alcohol); and local anæsthetics like novocaine (a derivative of coal-tar benzene), used as a substitute for the vegetable alkaloid cocaine.

Side by side with chloroform we may place the closely-related compound, iodoform, a yellow crystalline compound largely used as an antiseptic.

Following closely on the discovery of chloroform came the discovery of chloral, the first hypnotic to be produced commercially. But the dangers attending the use of chloral led to the search for, and discovery of, other hypnotics which are free from the bad qualities of chloral; and at the present day quite a number of synthetic hypnotics are known, of which perhaps the most familiar are veronal, and the inter-related compounds, sulphonal, trional, and tetronal.

If the introduction of anæsthetic chloroform marked a new era in surgery, a similar claim may perhaps also be made in connection with the substance adrenaline, the active principle of the supra-renal glands. This substance, when injected subcutaneously even in excessively minute amount, produces so violent a contraction of the arteries, that the blood is driven away from the injected tissues, and "bloodless" surgery becomes a possibility.

Adrenaline was isolated for the first time in 1901, from the supra-renal glands of sheep and oxen, close on 1,000 lb. of tissue (the glands from 20,000 oxen) being required to yield 1 lb. of adrenaline. It was not long, however, before the nature of the substance had been determined, and a process for preparing it synthetically on an industrial scale had been devised. It is now placed on the market under the name suprarenine.

The compound adrenaline formed in the glands of animals is optically active, and rotates the plane of polarised light to the left. It will, however, be understood from the previous chapter that the synthetic product is inactive and a compound of the two optically active forms. This racemic form, as it is called, is only half as active phsiologically as the natural occurring lævo-rotatory form, and it is therefore important to resolve the synthetic compound into its two optically active forms and to isolate the lævo-form. This can be done with the help of dextro-tartaric acid.

The difference in the behaviour of an optically active substance towards the asymmetric living tissues was emphasised in the previous chapter, and an excellent illustration of this property is afforded by adrenaline; for it is found that the physiological action (the increase of the blood pressure) is twelve to fifteen times greater in the case of the naturally occurring lævo-adrenaline than in the case of the synthetic dextro-adrenaline, and about twice as great as in the case of the inactive racemic form.

The great development which has taken place in recent times in the industrial production of synthetic drugs is due mainly to the discovery in 1887 of antifebrin, the first of a series of synthetic antipyretics which have entered into competition with the natural alka-

loid quinine. Strangely enough, the discovery of the antipyretic properties of antifebrin, a compound derived from acetic acid and aniline, and known in chemistry as acetanilide, was due to a mistake on the part of a laboratory boy who supplied this substance in mistake for naphthalene. During a pharmacological investigation of the substance, its strongly antifebrile action was detected, and from a chemical analysis, it was learned what the substance really was. The success of this first synthetic antipyretic soon led to the preparation and systematic study of the physiological action of a large number of other substances, but although hundreds, indeed thousands, of these have been found to have a certain medicinal value, only a few have, by their special properties or effectiveness, obtained a place in actual practice. Among synthetic drugs, however, there exists a ceaseless competition, and antifebrin has been largely superseded by newer and better drugs. Antifebrin, as we have seen, is derived from aniline, and is liable to undergo decomposition in the body, giving rise again to aniline, which exerts a toxic action ; and the continued use of the drug is therefore dangerous. By slightly modifying the composition of antifebrin, however, another compound, the well-known phenacetin, is obtained, a substance which possesses the valuable antipyretic properties of antifebrin, but is much less toxic.

One other synthetic drug of which special mention may be made is the anti-rheumatic, aspirin, a derivative of salicylic acid, which is itself a therapeutic agent of value, and is prepared from the coal-tar product, phenol or carbolic acid. Owing, however, to the large amounts of phenol used in different departments of synthetic chemistry, the amount obtained from coal tar is quite insufficient to supply the demands, so that phenol itself is now largely manufactured from coal-tar benzene.

Synthetic Perfumes

If the synthese of colouring matters and of drugs constitutes an achievement of the greatest importance, the significance of which is all too little realised, scarcely less notable are the successes of the chemist in the syntheses of those natural spices and perfumes, which have been valued by man from the earliest days. For thousands of years the volatile substances to which the different flowers and plants owe their odours have been prepared by distillation or by extraction by means of solvents. But in the past thirty or forty years the secrets of Nature have been largely unravelled, and the chemical laboratory has become odorous as a garden and filled with the perfumes of violet and rose, heliotrope, lilac, hyacinth and orange blossom ; and from the stills of the chemist there also flow liquids whose flavours imitate those of the apple, pear, pineapple, and other fruits, and which, in consequence, find application as artificial fruit essences. Although in a number of cases these perfumes and flavouring essences merely imitate the products of Nature, in other cases the chemist has succeeded in preparing the identical substances to which the flavour of the natural fruit or the perfume of the growing flower is due.

One of the first of these natural substances to be prepared by the chemist was the substance coumarin, the odoriferous principle of the sweet woodruff (Asperula odorata), a fragrant substance used in the preparation of the perfumes known as Jockey Club and New-mown Hay. This synthetic preparation of a natural odoriferous principle was speedily followed by the preparation of the flavouring material, vanillin, the active principle occurring in the vanilli bean. This substance is now manufactured from toluene, as raw material, and is of great commercial importance. To these earliest synthetic products numerous others have since been added, so that the main odoriferous principles of oil of wintergreen (methyl salicylate), oil of bitter almonds (benzaldehyde), hawthorn blossom (anisic aldehyde), lily of the valley (terpineol), ambergris (amgrein), and others, can now be prepared artificially. In the case of other synthetic compounds we have substances which, while not identical with the natural perfumes, closely resemble them, and are employed in large quantities, either as substitutes for the natural perfumes or for blending with them. Of these the most important are ionone, or imitation violet, imitation musk, and imitation oil of bitter almonds, or "oil of mirbane" (nitro-benzene).

The synthetic production of sweet-smelling substances, often at only a fraction of the cost of the natural product, has led to a great extension in the use of such substances, more especially for the perfuming of soaps, creams, and other toilet materials.

We have already seen how the synthetic production of the colouring matters alizarin and indigo have produced vast economic changes by the more or less complete supersession of the natural by the synthetic dyes. In the commercial production of camphor we have another illustration of the successful synthesis of an important natural product, without, however, the same disastrous consequences to the latter.

Camphor, one of the most familiar of substances, has been produced for many centuries in Japan, Borneo, Formosa, and other regions of the Far East. It is found chiefly in the leaves of a species of the laurel tree, the Laurus camphora, from which it is obtained by distilling the leaves or other parts of the tree in a current of steam. The camphor, being volatile, passes over with the steam and can be condensed in cooled vessels.

Camphor has for long been a highly valued substance on account of its therapeutic, disinfecting, and other properties, but the demand for the compound has been very greatly increased in the past forty years owing to its employment in the manufacture of celluloid or xylonite, and of explosives. Japan had, therefore, a valuable source of revenue in her practical monopoly of the production of camphor, through her possession of the plantations of the camphor-tree in Formosa, the extent of which, in the years following the Russo-Japanese War, she very greatly increased ; and the monopoly she possessed she sought to exploit to its utmost.

But the substance had lon attracted the attention of chemist and in spite of the difficulty of th problem, its molecular constitutio was at length unravelled, and th compound prepared syntheticall in 1903. Two years later, syntheti camphor, identical in all respect with the substance produced in th camphor-tree, was placed on th market in competition with th natural product.

But the Japanese camphor plan tations have hitherto escaped th

(Continued on page 576).

INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

Volume II | JUNE, 1923 | Number 11

BETWEEN OURSELVES

AT the annual meeting of the Manchester Chamber of Commerce, held in February last, a most lucid and pregnant address was delivered by the President, Mr. W. Clare Lees, O.B.E., J.P. He frankly declared that the fortunes of the Lancashire cotton trade were inseparately bound up in the welfare of India, and stated that the troubles of India, not less than those of Lancashire, dated back to the ill-starred attempt to fix the exchange value of the Rupee on the basis of 10 Rupees equal to one golden sovereign. Here are his words :—

"The Indian Government had maintained the Rupee for many years before the war at one and fourpence. The process of selling Council and Reverse Council drafts had worked so well, that when the disturbing influence of the fall in the value of the pound sterling and the rise in price of silver sent the Rupee up to well over two shillings, the temptation to attempt stabilisation overcame the dictates of prudence. The attempt was short lived. The balance of trade which had been for many years in India's favour, went heavily against her, and in a few months the Rupee was back at one and fourpence. But those few months were big with fate for Lancashire trade in general, and Manchester merchants in particular. Heavy purchases at very high prices had been entered into on the assumption that the two shilling Rupee would be maintained. When the goods which represented those purchases arrived in India, the market was falling, and a heavy loss, not only on exchange, but also in market values, was assured, with the result that wholesale repudiation of contractual obligations was attempted. Merchants have extended long accommodation and great help to Indian importers, but it is impossible that this incident which has brought loss and ruin to so many people can avoid having serious effects on the trade in the future. The confidence that contracts would be honoured has been shattered, and years of cautious trading will be required to re-establish it. Those who, under adverse circumstances, have done their best to stand by their contracts, will find that effort on their part a great asset in the future. It will enhance their reputation and increase their credit perhaps more than they at present realise. The immediate cause of the breakdown in Indian finance was the fact that a large and constantly favourable trade balance which before the war had been represented by an excess of exports over imports amounting to approximately seventy crores of Rupees, was suddenly changed into an excess of imports amounting to eighty crores. This was created by the disproportionate increase in the cost of manufactured articles which India imports in relation to the price of raw materials and food stuffs which she exports, coupled with the restriction of her European markets. The balance is now turning once again in her favour; Nature is intervening to correct the mistaken actions of man.

"The wheat crop this year is estimated to yield forty-five million quarters, as compared with thirty-one millions last year. The monsoon has been satisfactory, and India will again be in a position to export wheat. From May, 1920, to June, 1922, the balance of trade was against her every month, but from March last year she has had a surplus of exports every month with only two exceptions.

"Thus, conditions necessarily precedent to a revival of trade are being established from an economic standpoint, the one great obstacle so far as the cotton trade is concerned, being the fact that many of the old outstandings are still to be met, and a certain amount of the shipments still to be cleared. Let us hope that the desire on both sides to make a fresh start under more auspicious circumstances will lead to a more speedy settlement than has been possible up to the present.

"A great increase in the production and consumption of goods made in the Indian mills coming simultaneously with the diminished purchasing power of the population, has aggravated and postponed the recovery of Lancashire trade. In the years immediately before the war the Indian consumption of cotton piece goods was over four thousand million yards. Out of that total we sent from this country nearly three thousand million yards—being seventy per cent. of the total consumption. Foreign countries supplied between eighty and ninety million yards, or about two per cent., leaving the balance of

approximately one thousand two hundred million yards to be supplied by the Indian mills. In the year ending March, 1922, a change had taken place which accounts in a large measure for the short time we have been working in this country. Instead of consuming over four thousand million yards, the consumption dropped to two thousand eight hundred millions, whilst at the same time the production of the Indian mills increased by 45 per cent. to over one thousand seven hundred million yards—leaving the whole burden of the restrictive consumption which was aggravated by this increased domestic supply to be borne by this country.

"The effect of this has been felt by every man and woman in Lancashire. Translated into figures, it means that whilst we formerly supplied upwards of three thousand million yards a year to India, we have shipped during that period less than one thousand million yards. Put in another way, this loss of trade is equal to nearly two full days work a week for the entire trade for twelve months. Thus we see that our whole fortunes are bound up in the recovery of the Indian market, and the purchasing power of her teeming millions. Grave as these figures are, they have in them encouraging thoughts also The Indian mills have been fully occupied whilst we have been slack; it is reasonable to expect that the bulk of the increased demand which must surely come will be for the production of this country. If we strike a balance we can put it this way. We lost a trade equal to two thousand million yards a year. Five hundred million yards of that is probably permanent loss, native production having taken its place for the time being. That leaves one thousand five hundred millions which, if the people of India could afford to buy, they would buy from us. It is our turn next. In view of the fact that the balance of trade is once again in favour of India, we can confidently expect a gradual increase in her power of purchase, and that will be reflected in an increased demand for Lancashire goods.

"From this necessarily cursory and incomplete review of the general trade of the country, it will be seen that so far as the cotton trade is concerned, the volume of exports both in yarn and piece goods made a notable recovery from the low point touched in 1921. Had that increase been maintained, and the same velocity of improvement continued, we should have been facing 1923 with equanimity. Unfortunately, we are suffering a temporary set-back, largely due to the high price of our raw material, but the fact that world stocks cannot be large, coupled with the improbability of lower prices in the near future, must give confidence to overseas buyers. The increased purchasing power of our principal customer, India, coupled with the gradual fall in the cost of living in that country to which the Viceroy has recently referred, will, I have little doubt, make itself manifest as the year goes on. Let us hope that it will be in sufficient volume to insure employment to our workpeople and an adequate profit to all concerned. Meanwhile, those who are engaged in the cotton trade are not so selfish as to grudge the undoubted signs of recovery in other leading industries. I believe that tendency will continue."

* * *

Third Class—No Class

SOME months ago we received for review a copy of the Servants of India Society pamphlet No. 19 on "Railways and the Budget," by "Economy." We have studied this pamphlet with more than usual care, and the one thing which strikes us more particularly than any other is the author's plea for better third class railway facilities. We may regard the official view as somewhat as follows:—"That Indian railway fares have always been among the lowest, if not actually *the* lowest, in the world." Consequently, during the abnormal war period, in order to make "the railways pay their own way," it became necessary to increase the passenger fares. But while, says "Economy," the first class fares were increased only 48 per cent., the third class fares were increased 70 per cent. Now obviously when we consider the question of railway fares, we must also consider the means of those who have to pay them. Consequently it becomes a matter of comparing wages. Thus we find that in America an unskilled labourer, by spending one day's wages, can travel over sixty-three miles, whereas in India the same class of worker, by spending one day's wages, can only travel ten miles. Thus we find that "the burden which falls on the third class passenger in India is unequal not only in comparison with the lowest class passengers of other countries, but also in comparison with the higher class passengers in India itself." But "Economy" goes further, and he declares that the third class passenger in India has to suffer the inconvenience and discomfort of overcrowding, a lack of sanitary conditions on long distance journeys, a dirty condition of third class carriages, a lack of water supply on station platforms, inadequate food supply arrangements, a want of waiting rooms, insufficient booking-office facilities, and uncivil treatment by the railway staff. The first class passenger enjoys ample accommodation, electric light and fans, cushioned seats, clean and commodious bath rooms, dining cars, richly furnished waiting rooms, up-to-date railway hotels, and numerous other facilities. Naturally one would think that the railway companies were earning their revenue from the first class passengers alone. Yet, according to "Economy," the working of a first class railway carriage, on the broad gauge railways, at any rate, is carried on at a loss, whereas the third class carriage is earning a lively profit. Indeed, in India, the third class affords the backbone, if not nearly the whole body of the coaching receipts, and, so far as profit is concerned, there would be no great loss if first class were abolished altogether. In spite of all this, "Economy" quotes statistics to show that, apart from the abnormal war period when a proper relationship between supply and demand could not be maintained, accommodation has not been provided for the increased number of passengers, fares have been kept up at high levels, and discomfort upon discomfort and inconvenience upon inconvenience have been piled upon that milch-cow—the third class passenger. There is no monopoly in the world so far reaching and cruel in its scope and operation as a railway monopoly, and this is particularly true in India, where there exists a hybrid system of State ownership and company management, without a precedent or contemporary parallel in the rest of the world. The companies work the railways, but do not own them—the Government owns the railways, but does not work them. Small wonder that these evils fall with such severity on the poorest passengers, who travel third class because there is no fourth class, and who are left, therefore, without comforts and without conveniences. Under stress of necessity they are compelled to resume their deferred journeys at extra railway fares, and the third class passengers are thus driven to fill the coffers of the Government by

(*Continued on page 614.*)

INDUSTRIES

Conducted by FRANK DAWSON

THIS MONTH WE DEAL WITH THE PLANT REQUIRED IN A BISCUIT FACTORY AND WITH THE PROBLEM OF POWDERED COAL FIRING

Biscuit Making

This article has been prepared from particulars kindly supplied by Messrs. Joseph Baker, Sons & Perkins Ltd., London, and we are also indebted to the same firm for supplying the whole of the illustrations

THE manufacture of biscuits is a blend of craftsmanship and mechanism. The craftsman mixes the dough and chooses the ingredients from which the appetising biscuit comes, but he realises that he is forced to rely upon ingenious and complicated machinery to produce his biscuits at a commercial cost. No one can write adequately of the part played by the craftsman. A description of the machinery in use in biscuit factories, however, will, we think, be of interest to our readers.

A firm which ranks high for efficiency and workmanship is Messrs. Joseph Baker, Sons & Perkins Ltd., whose machinery is used in every country of the world for food preparing purposes, especially for biscuits, bread, chocolate, and confectionery. We are indebted to them for the information upon which this article is based, and for the photographs which accompany it.

The manufacture of biscuits is divided into five main processes :—

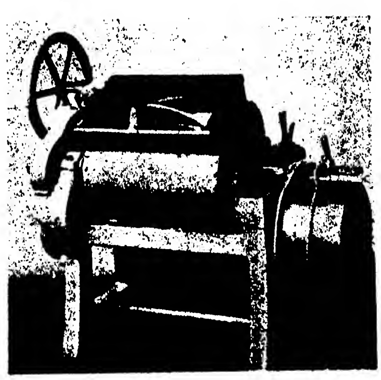
(1) Mixing the dough.
(2) Rolling the dough into sheets.
(3) Cutting the sheets into biscuits.
(4) Baking.
(5) Packing.

There are a number of extra processes, most of which aim at the decoration of the final product, *e.g.*, chocolate coating, icing, sandwiching, etc., etc.

Let us therefore consider the various processes, and briefly discuss the machinery for dealing with them.

Mixing.—The flour and sugar are sifted by machines on the floor of the flour room, and pass down a chute into the mixer. The other ingredients, such as fat, milk, ammonia, etc., are added direct into the mixer by hand. There are two forms of mixer—one for "soft" doughs, the other for "hard." The difference between a hard and soft dough lies in the proportions of sugar and fat in a mixing, *e.g.*, with a 280-lb. sack of flour a hard dough would contain up to 56 lb. of sugar and 60 lb. of fat, and a soft dough over 90 lb. of sugar and under 80 lb. of fat. The hard dough is elastic, but the soft is not.

The soft dough mixer is illustrated on next page. The mixing blades are mechanically raised or lowered into the removable mixing tub. It takes this machine about twenty minutes to mix the average soft dough. Mechanically, the point of chief interest is the worm gear which runs in an oil bath in the head drive. This makes for silence and efficiency.



Cylindrical Hard Dough Mixer

The hard dough mixer is cylindrical, with "⊔" shaped arms revolving at right angles to the spindle, the cylinder remaining stationary. A mixing in this machine takes anything up to 1¼ hours, according to the consistency of the dough. The mixing drum tilts over to throw the finished dough into a trough, which, like the movable tub of the soft dough mixer, is wheeled to the brake. (For batters for drop biscuits, mixings are made in special machines of whisk-like character.)

Rolling Out.—The brake consists of a pair of heavy steel rolls with reversible motion, with a table on either side. The rolls are adjustable, so that the dough may be reduced to any required thickness. The dough is passed backwards and forwards through the rolls until the right thickness and surface skin is obtained, and the sheets are then passed by hand on to the feed table of the cutting machine.

Cutting.—The latest type of cutting machine is illustrated on the next page. Here the sheets are fed into the first set of gauge rolls (whose primary function is the joining of the sheets), and on to a web which feed in turn into a second pair of gauge rolls. The latter put a fine surface on the dough, and eliminate all traces of the join. Thence the dough passes on a web which is moved forward by the action of ratchets and pawls in the skips necessary for the size of biscuit which is being produced. This carries the dough under the cutters. The action of the cutter is as follows :—

The actual cutter "cup," type for printing, and "docker-pins" for making the holes, are so set in relation to one another that they all perform their functions on the downward stroke. When the cutter begins its upward stroke, an ejector plate removes the biscuit if it is sticking, the plate is picked up by the cutter head, and the whole set of cutters completes the upward stroke. The cutting and stamping is done by an eccentric, and the ejection by weight.

Some Recent Developments of Powdered Coal Firing

BY J. S. ATKINSON

The following article raises the question as to whether we shall, in our time, see coal mined by machinery and brought to the surface in the form of powder. Since our great industries rely upon the obtaining of a low-priced fuel, such a question should receive most serious consideration, and at least there is no reason why coal should not be brought to the surface very much more cheaply than by present practice if improved mechanical devices are adopted.

AN engineer recently commenced a paper on fuel economy and kindred subjects by stating that lump coal should, for economic reasons, be obtainable at a lower price than very fine or dusty coal of the same heating value. He made this statement because, in his opinion, coal in the form of fine powder was nearer to the form when it could be burnt with the highest efficiency. If this statement is true—and the author believes it is—the question arises as to whether we shall, in our time, see coal mined by machinery and brought to the surface in the form of powder. On this question the author would not like to express an opinion; at the same time, when it is considered that most of our great industries rely upon a low-priced fuel, this question should receive most serious consideration.

It may not be beyond the ingenuity of man to devise some mechanical means for winning coal in this way and bringing it to the surface very much more cheaply than is the present practice. The author would not suggest that all, or even the majority, of our industrial coals should be burnt directly in their powdered form and all the valuable by-products lost, but such will be done with very many of the low-grade fuels, whilst in the majority of cases the better grades will be treated by some successful form of low-temperature carbonisation and the residue burnt in its powdered form. Here, again, the author would like to qualify his statements by saying that he does not consider that all industrial furnaces, either boiler or for heat treatment, should be fired by powdered fuel, but that in some cases gas and even oil will hold their own.

The preparation and utilisation of powdered coal may be divided under the following headings: (1) Drying—where this is necessary; (2) pulverising; (3) burning; and (4) the removal of the incombustible residue.

Drying

This operation has been the cause of a good deal of controversy. On the one hand, the removal of the moisture in a fuel in a combustion chamber at a very high temperature has been considered unnecessary when it can be driven off at a moderately low temperature in a dryer. On the other hand, the utility of drying coal in an inefficient dryer when it can be done in an efficient furnace also has been questioned.

Dryers of many types have been designed, but the rotary dryer seems to have been the one that has held its own. It is simple in construction, has a low maintenance cost, does not require much power, whilst its efficiency, though low, will compare favourably with other forms when all sides of the question are considered. The efficiency of the rotary dryer varies from 50 to 70 per cent. The latter figure may be on the high side.

Those at present available include the direct and indirect-fired types. The power required for driving a rotary dryer is quite small, as the shell rotates very slowly, requiring about 2 h.p. for a machine treating 2 tons per hour, 4 h.p. for 6 tons per hour, 7 h.p. and 10 h.p. for treating 14 and 25 tons per hour respectively.

Several precautions should be taken when considering the installation of a dryer of this nature. In making a selection, it is better to choose one on the large rather than on the small side. When it is small for its work, it dries the coal at too high a rate and the coal is discharged at the dry end, deprived of some of its volatile content. A present-day dryer is a somewhat cumbersome and hot cylinder; a good deal of radiant heat is given off, rendering the immediate vicinity uncomfortably hot. Therefore a suitable position should be carefully chosen.

The capacities and sizes of some American dryers are as follows:—

Tons per hour.	Dimensions. ft. in.			ft. in.	
4	3	0	×	30	0
8	4	6	×	30	0
10	4	6	×	42	0
20	6	0	×	42	0
25	6	6	×	42	0

The author has watched the development of a rotary dryer which has aimed at diminishing the dimensions given above. British practice demands dryers of dimensions somewhat larger than these, owing to the higher moisture content of British coals. American coals are usually much drier. When first trying to reduce the overall dimensions of a rotary dryer, the firm with whom the author is associated developed a dryer on a horizontal axis, making use of veins running in a helical manner along the shell. These veins were broken, and lifting plates were placed between them. In this way the coal was detained for a longer time in the dryer-casing, and some advance was made towards a reduction of the overall dimensions.

A further system of drying is now being studied, the dryer being very much smaller than any of those referred to in the foregoing. The proposal is to make use of sensible heat from the boiler combustion chamber as the drying agent. Gases will be taken from the chamber, diluted with atmospheric air, until the resulting temperature is below the flash-point of the coal, but much higher than current drying practice, and passed through a rotary dryer of restricted size. After the gases have functioned as a drying agent, they will be exhausted from the dryer by means of of a fan, and returned again to the combustion chamber, through, or near, the burner. In this way, high-temperature gases may be used for drying, thus reducing the time factor and the size of the dryer, whilst any dust which is carried through, or any volatiles which are driven off from the coal, will be burnt in the combustion chamber near, or at, the burner.

This, the author believes, is an entirely new departure in drying, and the invention has been covered by a Provisional Patent.

With regard to recent developments, the tendency is towards either the entire elimination of any form of dryer or reducing the size of this apparatus to a minimum. There are many installations of unit pulverisers employing no dryers at work in this country and on the Continent.

Pulverising

The problem of pulverising is very closely connected with that of drying. There are several mills of the grinding type, the makers of which specify in almost every case that the drying should be carried out until not more than 1 per cent. of moisture remains. The same remark applies to ball and tube mills. All the mills are of the crushing or of the grinding type. Some of them rely upon finely-meshed screens in order to obtain the requisite degree of fineness. In the grinding operation, if the moisture contained in the coal is much above 1 per cent., the screens have a tendency to become clogged. The author has known the Bonnot mill deal with coal having a moisture content of 3 per cent., but it is doubtful whether the mill could deal with coal having a higher moisture content. This is the mill which the author has had most opportunity of watching. This mill of course relies upon the crushing action, but does not make use of finely-meshed screens. A Bonnot mill has been working at the Borough of Hammersmith Electricity Works for some two years. Extensions to this plant include a Sturtevant mill.

Mills are usually driven by an electric motor by means of a belt, or silent chain-drive, the sizes of motors required for different capacities of three typical mills being as follows :—

Bonnot Mill.

2,500 lb. of coal per hour	—	25 h.p.
5,000	,,	,,	50 ,,
10,000	,,	,,	75 ,,

To this power has to be added, for the air separator—7½ h.p., 12 h.p. and 25 h.p. respectively.

Fuller Mill.

2,500 lb. of coal per hour	—	20 h.p.
5,000	,,	,,	35 ,,
10,000	,,	,,	50 ,,

Sturtevant Mill.

2,500 lb. of coal per hour	—	20-24 h.p.
5,000	,,	,,	35-40 ,,
10,000	,,	,,	45 ,,

In the latter case a 12-h.p. motor is required for the separator and a 10-h.p. motor for the elevator.

Fig. 1. Turbo-Pulverising Units

The author is more in favour of the unit system of pulverisation than the central system, of which rotary dryers and the grinding mills referred to form a part, together with the necessary conveyors and elevators. The tendency is in this direction, even in the United States, where bulk supply and large plants are the order of the day ; this change of opinion seems to be very marked.

The unit pulveriser which the author's firm developed in this country and in France has proved its usefulness, when it can be said of it that, while we have only been working seriously on the problems since the latter days of 1919, three hundred and ten of them are in everyday use, and some remarkably efficient results have been obtained. This pulveriser, which is called the turbo-pulveriser, is a mill of the true pulverising, or impact type, as compared with the grinding mills referred to previously. The origin of the principle goes back some forty years to an English inventor. In developing this machine it was found that a number of further Patents could be taken out, covering certain improvements.

Three of these machines are shown in Fig. 1. It will be seen that the machine consists of an automatic feed, three or more pulverising compartments, and a fan. Air is introduced at the feeding-end of the machine, and a further supply, of what may be called "secondary" air, between the last pulverising chamber and the fan. This air may be at atmospheric temperature or pre-heated. The idea of pre-heating the air going to a pulveriser is quite an old one, and Messrs. Fraser & Chalmers made use of this in their original "Bettington" boiler. The turbo-pulveriser will take lumps of coal up to 1 in. in diameter and reduce them down to a very fine powder ; it will deal with coal which is what may be termed "commercially" dry. At one installation a turbo-pulveriser has been in operation for some considerable time, and no attempt at drying the coal has been made. The coal arrives in barges, which are often leaky, and has been put through the turbo-pulveriser with up to 12 per cent. of moisture with good results. Coal with 15 per cent. of moisture has gone through the machine, but then the wear was rapid, and the horse power necessary for pulverisation was much increased.

The power required for a turbo-pulveriser when this machine is working at, or near, its normal capacity, or upon a slight overload, compares well with the power required by other mills, when it is considered that the machine supplies air for combustion at the same time that it pulverises the fuel. Of course, the moisture content of the coal has a great effect upon the power required.

The following powers may be given as examples with coals containing about 8 per cent. of moisture :—

1,100 lb. of coal per hour	—	14 h.p.
1,400	,,	,,	15½ ,,
2,700	,,	,,	37 ,,

It will be noticed that the power required for 1,400 lb. of coal per hour is, in proportion, on the low side when compared with the other two, but the explanation of this is that this reading was taken from a machine with a normal capacity of 1,000 lb. of coal per hour, run on an overload, which is the most economical way of running these machines, in so far as the power required is concerned.

Recent figures relating to the fineness of pulverising coal have shown that a coarser pulverisation than has been recommended by American practice gives as good results. Fine pulverisation is undoubtedly, in theory, an advantage, but after we have reached a certain limit the gain is so infinitesimal that the greatly increased horse-power required by far outweighs

any advantage. By means of a turbo-pulveriser with a very slight modification, practically any degree of fineness can be obtained, but the fineness tests given in the following table show how the power required increases.

Output of coal per hour.	Horse-power.	Fineness.	
		Through 100-mesh sieve.	Through 200-mesh sieve.
		Per cent.	Per cent.
1,980 lb.	42.5	96	82
2,700 lb.	37	94	75

Expressed in terms of 1,000 lb. of coal per hour, the power required is 21.46 and 13.7 h.p. respectively, for the outputs mentioned in the foregoing table. Although these figures are based upon an average of a number of tests, they cannot be looked upon as entirely representative, owing to the fact that moisture in the coal has a very considerable effect upon the power required. If the coal will ignite quickly, burning with a minimum of excess air, say 15 per cent., and leave no trace of CO gas in the flue and no trace of unburnt carbon in the ashes, then the coal is sufficiently fine. With regard to actual screen-tests, the best figures for these, from a practical point of view, will vary with different fuels; anthracite should be powdered more finely than a bituminous coal, while the length which the flame has to travel will also affect this question. The average powers for a turbo-pulveriser are best expressed as a percentage of the power developed by an efficient boiler plant, and with coals of various calorific value. Fig. 2 shows these percentages, and it will be seen that 2 per cent. is a very fair figure to take.

Magnetic Separators

Magnetic separators have been referred to as an essential part of a powdered-fuel plant. The author, however, does not think they are

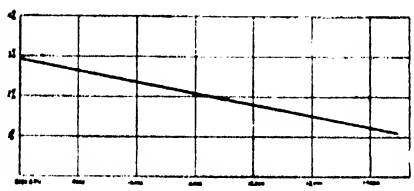


Fig. 2. Percentage of Boiler Power Required to Prepare Powdered Fuel

essential, though they are an advantage in certain cases. There is no doubt that a magnetic separator, when installed, would somewhat reduce the maintenance charges, while the unlikely occurrence, with a properly designed plant, of a breakdown through large quantities of "tramp iron" may be avoided. A good rule to follow is to make the plant capable of passing "tramp iron" to an extent which is met with in the average coals. But if the plant is large and the pulveriser or pulverisers are fed by means of a coal-handling plant, it is advisable to instal a separator in or over one of the conveyors. If, however, only one unit is installed, it is doubtful if the first cost of a magnetic separator warrants its installation.

Magnetic separators are either of the pulley type or of the static type. The pulley type is divided into two sub-types, namely: the pulley which has a magnetic field right round its circumference, or the pulley which has a magnetic field, say, five-eighths of the circumference. The static magnetic-separator is an electro magnet suspended a few inches above a belt conveyor in such a way that it draws any "tramp iron" mixed with the coal from among the coal on the belt.

Combustion of Powered Fuel

This subject has received perhaps less attention than the two foregoing operations, and yet there is more to be learnt in this connection and many more pitfalls than in the design of a satisfactory dryer, a grinder, or a pulverising mill. It is not enough to lead powdered fuel, of the right degree of fineness, thoroughly mixed with the correct amount of air for its combustion, into a large refractory-lined chamber. The shape, the volume of the combustion chamber, the position of the ash pockets, direction of the flame and velocities, must be all carefully considered from a practical and technical point of view. A large combustion space is necessary, but, to reduce radiation losses, this space should be so arranged that the bulk of the heat is near to, or on, its work. Fig. 3 shows the arrangement of a turbo-pulveriser firing a "Woodeson" boiler. A large combustion chamber is shown, but it is so arranged that the flame is parallel to, near to, or under, the boiler tubes. If the same space was made use of as diagrammatically shown in Fig. 4, it is obvious how much more heat would be lost by radiation and how much would be lost owing to the fact that the most luminous flame is not adjacent to the water tubes. The velocity also is of first importance, and most of the earlier failures in powdered-coal firing could be traced to too high velocities.

The pressure in a powdered-fuel-fired boiler furnace should be so near to what may be called a balanced draught that there should be a slight vacuum at the base, a neutral pressure in the middle zone, and a slight pressure at the first pass. The powdered coal and air at the burner should be of sufficient pressure to allow the flame to wander in and to avoid anything in the nature of a blow-pipe action, causing scouring and numerous other troubles. It is found that, owing to

(*Continued on page 634.*)

Combustion Test on Turbo-Pulveriser at Philadelphia Power Station.

Time.	CO_2	O_2	CO	Draught Blr. front.	Flue gas. Temp.
				in.	Deg. Fah.
11.25	16.8	0.6	nil	0.05	490
11.40	16.0	2.2	nil	0.05	500
12 noon	15.2	2.5	nil	0.05	487
12.30	16.4	1.8	0.5	0.04	446
12.55	16.5	1.5	0.3	0.04	430
2.30	15.9	2.0	nil	0.06	440
2.50	12.5	6.9	nil	0.02	442
3.10	10.9	—	—	0.4	435
3.45	17.0	1.5	nil	0.07	446
4.15	14.7	4.3	nil	0.04	430

Note.—At 12.20 p.m. combustion was intentionally arranged to be incomplete. Between 12.55 p.m. and 2.30 p.m. normal conditions were restored, and at 2.45 p.m. an attempt was made to raise the superheat by increasing the speed of gases through the boiler. The boiler damper was raised a further 1 in. At 3.0 p.m. the damper was raised another 1 in. After 3.10 p.m. normal conditions of complete combustion were restored.

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

Low Temperature Carbonisation (xiii)

(THE "RICHARDS-PRINGLE" PROCESS)

By DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min.E., Mem. Am. Soc. M E., A.I.Mech.E., etc.

THIS process is the invention of R. S. Richards and R. W. Pringle, and is owned by Messrs. The Smokeless Fuel Syndicate Ltd., of London. It consists essentially in carbonising coal in the form of slack, or in a slightly crushed condition, at about 1,000-1,100 deg. F. (540-595 deg. C.), in a series of deep wedge-shaped trays 4 ft. long, 12 in. deep, and 3 in. average width, arranged transversely. These trays are attached one behind the other to a chain conveyor, and travel very slowly through a carbonisation chamber 40 ft. long heated externally by producer or other gas in combustion chambers. The time to travel completely through the chamber is about three hours, the raw coal being fed automatically into each tray as it enters the carbonisation chamber and the residual low temperature fuel in the trays being discharged at the end as these pass round over a large diameter driving wheel, the empty trays passing back underneath, the gaseous and volatile products evolved escaping through openings at the top.

The first experimental plant on these general lines was erected at Bermondsey in 1909, consisting of 15 ft. 0 in. carbonising chambers, and worked for about three years, a large amount of experimental work being undertaken, and many different coal tests. Subsequently a somewhat larger plant was erected at the Thorncliffe Works of Messrs. Newton, Chambers & Co. Ltd., and further work carried out. The matter was then temporarily abandoned because of the difficulties due to the war, but was afterwards taken up again, and the present large experimental plant installed at Dover Gas Works in April, 1922, illustrated in Figs. 1 and 2, embodying all the improvements resulting from the above experience, together with a new type of tray, and at the present moment the plant is in active operation.

Perhaps the most convenient way of explaining the "Richards-Pringle" process is to follow the patents :—

The original patent is 15643/1909, taken out by R. S. Richards and R. W. Pringle, which applies to the carbonisation of coal in a general way at unstated temperatures. This embodies essentially a long muffle furnace, horizontal or inclined, which has travelling through it very slowly a continuous series of open-ended trays attached to an endless travelling chain or similar device.

The upper part of the conveyor passes through a carbonising chamber constructed of steel plates closely enveloping the chain of trays, the chamber being heated by means of surrounding combustion chambers, or these chambers may be above and below the travelling chain. The coal is thus carbonised in the trays as it passes through the heated chamber, the gaseous and volatile products being driven off the coal charge in the trays and the residual fuel being discharged automatically at the other end. The coal is fed automatically into each tray as it enters the chamber, the heating being carried out by any suitable means, such as producer gas or the rich low temperature gas.

After emerging from the carbonising chamber the conveyor passes through a cooling chamber, so that the fuel is cooled down before coming out into the air and quenching water is not necessary. The travelling chains then pass downwards over large driving wheels, and the trays empty out their contents, returning empty underneath.

A second and subsidiary patent, 22421/1909, deals with a special design of tray suitable for the process. These early trays were of considerable width relative to their length, divided by longitudinal ribs or dividing walls into a transverse series of open-topped compartments, these ribs or dividing walls being arranged so that each of the compartments tapered towards the bottom. The body of the tray was made of thick sheet iron, and the dividing walls of plates bent to a channel shape, and the whole arrangement is riveted to each link of the two conveying chains. The object of these compartments was to divide up the layer of coal as much as possible so as to promote the conduction of the heat to every part of the charge. It was found that with the simple trays of the original patent it was difficult to carbonise uniformly layers of over 2 in. thick, and with the above device this could be doubled, whilst at the same time the speed of travel of the trays could be increased.

A further patent is 25019/1909, which now relates to the application of the process specifically to low temperature carbonisation. There is very considerable difficulty in applying a continuous carbonisation process of this character to high temperature carbonisation, and ever since the days of Clegg, who in 1815 made the first attempt, the problem of carbonising coal at high temperatures on the continuous principle in a chain of small receptacles, on the lines, for example, of the continuous brick kiln, has remained unsolved. Some of the difficulties are the impossibility of getting any movable mechanism to

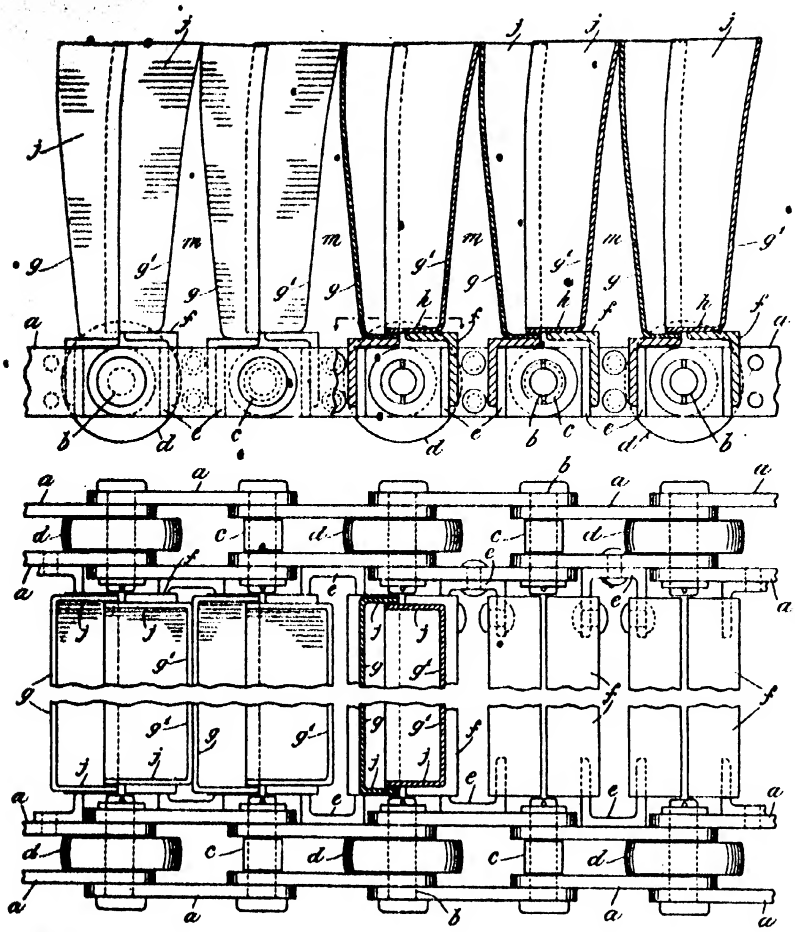


Fig. 9

stand the high temperature, the difficulty of making tight joints with the excessive expansion and contraction, and the fact that the sudden heating is apt to form a non-conducting crust of coke on the outside of the charge and prevent the inside from being thoroughly carbonised.

Messrs. Richards and Pringle were of the opinion, however, that under suitable conditions there is nothing to prevent this method being a success for low temperature carbonisation, say at 1,000-1,200 deg. F. (540-650 deg. C.) at the outlet, especially for the utilisation of refuse and other coal in a fine state of division. The advantages of carbonising coal in large separate trays of this description are that each small charge of coal is handled quite separately, there is no jambing, pressure strain, or excessive wear and tear in the whole process, and also the time of carbonisation is reduced. Also the carbonisation is automatically fractional in the sense that as the charge travels slowly through the heated chamber, the progress of the decomposition of the volatile matter changes, and by a suitable arrangement of ascension pipes one behind the other the gaseous and volatile products are selectively extracted from the carbonisation chamber. For the manufacture of smokeless low temperature household fuel, the trays after carbonisation pass into a cooling chamber, as otherwise, of course, the fuel would take fire because of the remaining volatile content.

The main "Richards-Pringle" patent for low temperature carbonisation is 15933/1915, taken out by R. S. Richards and Messrs. The Smokeless Fuel Syndicate Ltd., London, including various improvements on the original patents already described.

The arrangement consist of an upper longitudinal carbonising chamber of rectangular section, with arched top and lower chamber, both surrounded by firebrick, each of these tubular chambers terminating in a separate chamber containing a drum to carry the chain conveyor with the carbonising trays. These trays were made to overlap, so as to form one continuous longitudinal trough in the carbonising chambers, passing first through the upper and then through the lower chambers. The combustion chambers for heating are situated between the upper and lower carbonising chambers, and the coal is charged automatically at one end of the conveyor and emerges at the other as low temperature fuel. The combustion

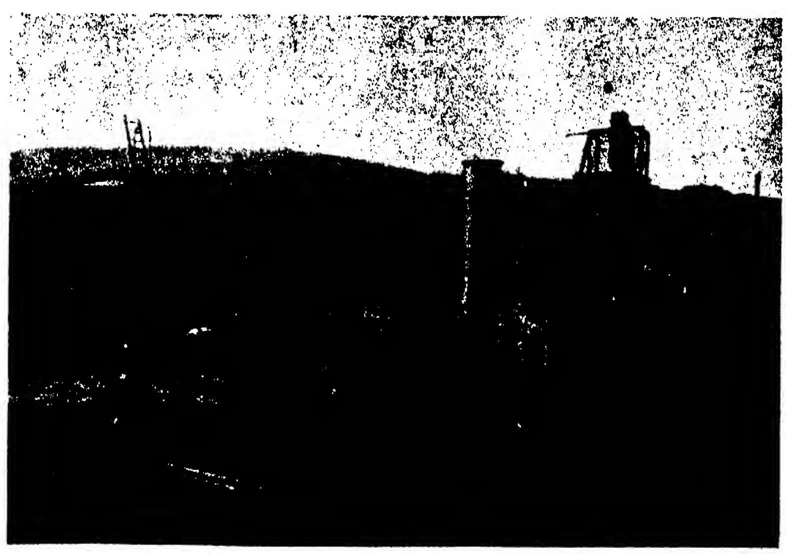


Fig. 1. "Richards-Pringle" Large Scale Experimental Plant now working at Dover

Fig. 2. Another View of the Plant, Fig. 1 showing the Coal Feed Hopper End

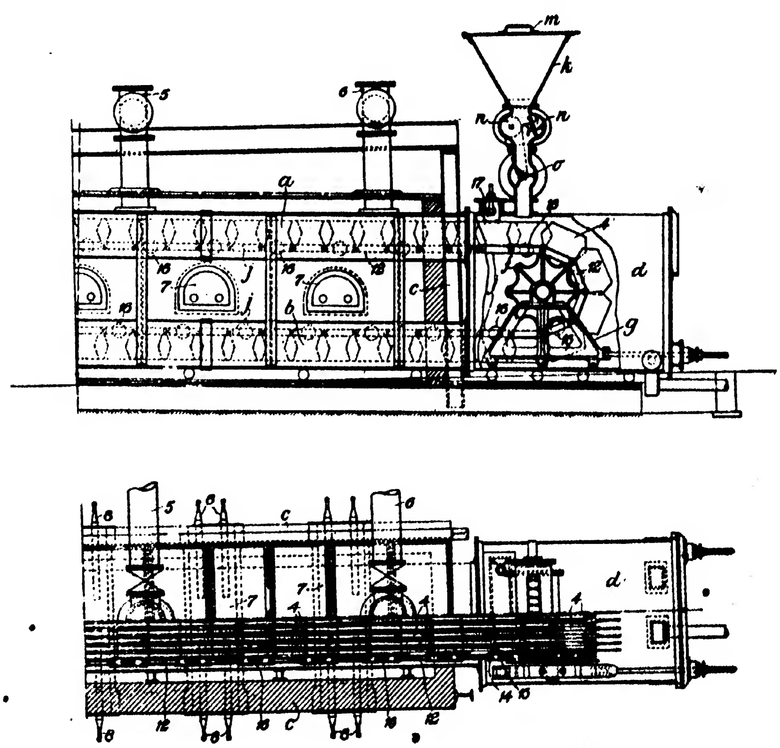
chambers are so designed that an even temperature can be maintained throughout the entire length of both carbonising chambers, or sections of the chamber can be arranged to be at different temperatures.

The arrangement is illustrated in Figs. 3, 4, 5, 6, 7 and 8.

Figs. 3 and 5 are a longitudinal elevation partly in section, 4 and 6 are the corresponding plans, and Fig. 7 is a cross section of the tubes and furnace. In these drawings A is the upper tubular chamber, and B the lower, connected by suitable framework, C being the surrounding structure. D (Figs. 5 and 6) is the external chamber at one end, which connects the upper and lower tubular chamber, C (Fig. 8) being the external chamber at the other end. In the external chamber, D is a polygonal wheel F, mounted on a carriage G running on wheels, so as to adjust the slack, and H is a similar wheel in the other chamber E. J is the chain conveyor which passes round the two polygonal wheels and travels through the upper and lower tubular carbonising chambers. The axles of the wheels carrying the chain conveyor are mounted on a carriage by means of adjustable bearings either inside or outside the chambers. K (Fig. 5) is the coal feed hopper, with a self-closing door (M) and a gas-tight coal feed valve arrangement consisting of a pair of feed-rollers and a chambered valve O, so as to discharge the coal on to the chain J. The drive of the chain is by means of a worm P on a shaft Q, geared with a worm wheel R in the chamber C, S being a series of prongs mounted on a shaft T, counterbalanced by weights U.

At the other end (Figs. 3 and 4), 1 is a discharge chamber of sheet metal for the low temperature fuel **when it leaves the conveyor, 2 being a cone valve to close the chamber exit, and 3 a self-sealing door, so that the whole arrangement can be kept closed, and worked, if necessary, above or below atmospheric pressure.** This chamber is cooled on the outside by a stream of water, and the fuel allowed to accumulate for a considerable time until it is cool.

In this patent the conveyor for carrying the coal as it is carbonised was formed, as already stated, of troughs or trays (4) fluted longitudinally, the rear end of the leading trough lying within the forward end of the following trough in the upper chamber, the coal lying in the flutes of the troughs, which form longitudinal channels, the gaseous and volatile products from the upper longitudinal chamber passing away through exit pipes 5 and 6. It was subsequently discovered that with caking and general high volatile fuels there was often a difficulty in discharging the fuel from the trays, and consequently an improved transverse type of carbonising "V" shaped trough was invented, and is embodied in the present plant at Dover. This is protected by patent 122013/1918 (Edward Batty), which has been purchased by Messrs. The Smokeless



Figs. 5 and 6

Fuel Syndicate Ltd., and is illustrated in Fig. 9. It consists essentially of links A and rollers D, forming a chain, with trough-shaped brackets E mounted on the inner links. Supported between the two chains are cross bars F, with plates (G, G1) flanged at the bottom and sides. The bottom and side flanges of one plate overlap the bottom and side flanges of the adjacent plates, the plates G on one link and G1 on an adjacent link and flanges form the enclosing walls of the transverse troughs for the coal. Between the troughs a space (M) is exposed to the heat of the furnace. On reaching the end of the travel, when the chain passes round the driving drum, the transverse troughs containing the charge of low temperature fuel are emptied over, and at the same time open, whilst the bottom flanges rise up and the contents are discharged without any difficulty of sticking. 7 is the combustion chambers between the tubular chambers A and B, heated by gas-fed burners I. The gaseous and volatile products pass off through vents 9 into the space 10 between the chambers and the walls of the structure, and then pass over the upper chamber and out by the flue 11 into a hydraulic main in the ordinary way.

The present single unit plant at Dover (Figs. 1 and 2), constructed in accordance with these patents, has a capacity of 15 tons of coal per 24 hours, and for convenience most of the heating has been undertaken either with town's gas or with oil, and a considerable number of coals have been investigated, chiefly Kent and Warwickshire varieties. The experiments so far have been very successful, and a number of practical advantages are claimed for this method. In the first place it is very cheap to erect, costing only about one-third of many low temperature installations, and at the present time a 90-100 ton plant per 24 hours would only cost about £30,000, including the by-product plant. Also the wear and tear is very small, the rate of travel being only about 1 foot in 5 minutes, whilst the power required to drive the plant is very small, less than 4 h.p. for the standard 15-ton unit, the present Dover plant. Further, the labour costs are claimed to be very low. For commercial working it is the intention to erect the plant in batteries of 6 units side by side, corresponding to 90-100 tons output per 24 hours, and the labour required for this battery would be eight men and two foremen complete, as the whole process is almost entirely automatic.

As regards the yield from the "Richards-Pringle" process, I am not in a position to give definite figures. Messrs. The Smokeless Fuel Syndicate Ltd. have always acted on the principle of giving no figures that are not absolutely authentic, and the results of long trial, and although they have very kindly given me privately the results they have obtained, these are not yet available for publication. I can say, however, that the yields are approximately the average for low temperature carbonisation for gas, oil, motor spirit, ammonia, and smokeless fuel, and 70 per cent. small non-coking coal can be used. The quality of the oils obtained is very good, and is best illustrated by the results of a detailed analysis (May, 1922) of a typical sample by the West Ham Testing Laboratory, as follows:—

The specific gravity of the crude tar was 1.056. The tar as received was submitted to a straight distillation, and yielded :—

	By Volume.	Specific Gravity.
Light Oil 0-170° C. ...	11.01%	0.8685
Heavy Naphtha 170-200° C.	6.71%	0.903
Carbolic Oil 200-240° C.	8.83%	0.9975
Creosote Oil 240-270° C.	5.33%	1.010
Anthracene Oil 270-350° C.	14.37%	1.034
Ammoniacal Liquor ...	32.55%	1.011
Pitch (by weight) ...	21.11%	

A fractional distillation of the light oil, using an eight pear column, the distillation being at a uniform rate, yielded :—

	By Volume.
Benzol 0-95° C.	6.98%
Toluol 95-125	14.91%
Solvent naphtha 125-170° ...	58.68%
Residue and Loss	19.43%

The carbolic oil and creosote oil were tested for their cresol and phenol content, and showed :—

	Phenols & Cresols by Volume.
Carbolic Oil	65.5%
Creosote Oil	42.1%

The ammoniacal liquor contained 0.68 per cent. of ammonia as NH_3. This existed almost entirely as thiosulphate, the sulphur content calculated to thiosulphate giving a content of 1.99 per cent. ammonium thiosulphate.

The free carbon in the tar as received was 1.8 per cent.

The residual oil after expulsion of water and light oil to 170 deg. C., was tested for fuel, and showed :—

Ash	0.88%
Sulphur	0.53%
Cal. value	16,241 B.Th.U. per lb.

Some amount of caution must be used in accepting too strictly the figures given, as the extreme amount of water present rendered necessary a lengthy and very slow distillation,

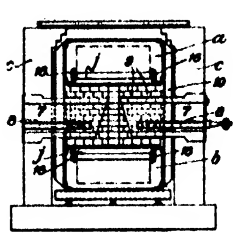
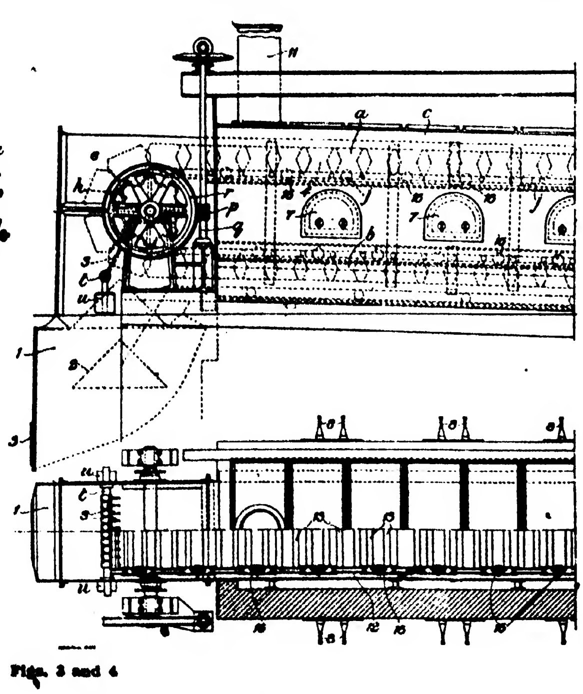


Fig. 7



Figs. 3 and 4

which made possible a certain amount of cracking of the higher fractions with a corresponding increase in gases which are lost, and an increase in light oil. Assuming, however, that no cracking did actually take place, the dehydrated tar would, on distillation, yield the following figures :—

Specific gravity of tar ...	1.078
Free carbon content	2.67%
Light oils in tar	16.32%

and the full distillation figures would be :—

	By Volume.
Benzol 0-95° C.	4.14%
Toluol 95-125° C.	2.43%
Solvent Naphtha 125-170° C.	9.58%
Loss and residue on redistillation of light oil ...	3.17%
Carbolic oil 200-240° C. ...	13.09%
Creosote Oil 240-270° C. ...	7.90%
Anthracene Oil 270-350° C. ...	21.30%
Pitch (by weight)	31.30%

The residual low temperature fuel contains on the average 8-10 per cent. of volatile matter, and is absolutely smokeless, burning with a high emission of radiant heat, and also easily ignited, as usual. Much of it has been sold locally in Dover both for household use and for steam motor wagons, and it is claimed to be very hard, and to stand travel well.

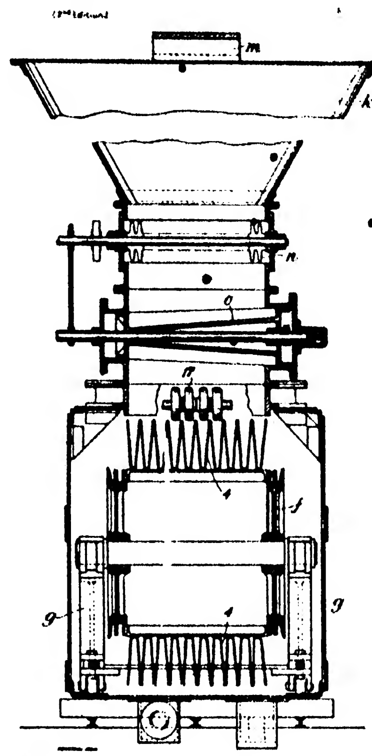


FIG. 8

Some typical analyses of raw coals and the subsequent low temperature fuel are given on page 603, as a result of tests by the West Ham Testing Laboratory.

The fuel has also been tested on a number of occasions by heating the gas retorts in Dover Gas Works, instead of ordinary coke. Typical tests on four benches of retorts, for 48 hours each, under identical conditions, gave results of 4.0 tons Hardwick furnace coke, 4.20 tons "Richards-Pringle" smokeless fuel, and 4.60 tons ordinary gas coke.

Air Filtration for Industrial Purposes

(*Concluded from page 606.*)

and dry type, in order that the incoming air may be both cooled and filtered. It will readily be understood that no excess moisture must enter the alternator windings, and for this reason the wet portion of the filter is designed in such a manner that the cooling water passes over exposed surfaces with which the air will come in contact when passing through the filter. This principle has proved to be more efficient than the water-spray type.

For Cleaning Boiler Flues

The subject of industrial air filtration would not be complete without some reference to the suction method of cleaning buildings, flues, and so forth. The ordinary suction or vacuum cleaner is a well-known and established apparatus, and the principle has now many different applications. One which will appeal specially to the factory owner is the application of the method for cleaning boiler flues. The general arrangement of such a plant is as follows :—A vacuum pump or exhauster is used to create the necessary suction in the pipe line ; a dust container vessel is placed in the air main to collect the soot and dust ; and special nozzles are attached to the end of the pipe line which enters the boiler flues.

It is also necessary to have what is termed an intercepter vessel in the air main, between the exhauster and the container. The function of this vessel is to remove all trace of dust particles from the air which may have escaped past the container. Otherwise such dust would pass through the exhauster and would have disastrous results in the course of time. The intercepter consists of a vessel containing specially constructed baffles immersed in water, and the air in passing through the vessel is thoroughly cleaned.

When the boiler plant is specially designed for the cleaning of flues by the suction apparatus, hopper-shaped pockets are built in the flues in order that the soot and dust will accumulate at these points. Pipe connections are made to the bottom of each pocket when the collected soot and dust can be removed at any time, even when the boiler plant is in operation.

The advantages of this system over the old hand method are obvious. Boiler flue cleaning is not at the best of times very inviting, and for this reason the operation is often scamped at the expense of boiler efficiency. When the suction method is installed, however, the operation becomes a merely mechanical one, apart from the directing of the suction nozzle in those cases where special collecting pockets have not been arranged for.

Value of Water Filtration for Swimming Baths

This article will be of particular interest to those who are interested in public health questions. The Pulsometer Engineering Co. Ltd. have supplied us with the data and illustrations.

IT is one of the most satisfactory signs of the time that public health questions are receiving so much attention, for the healthy mind in the healthy body is more than ever an essential to national progress. In all deliberations on the subject, the problems connected with the supply of water for recreation purposes must occupy a prominent place, and a study of the progress that has been made in this respect within recent years seems opportune.

One important city in the North of England has made noteworthy strides in this direction, and the results of their experiments are likely to have a far-reaching influence on present-day practice. In the winter of 1921-1922 the corporation installed a battery of filters at one of their public baths, consisting of three 7 ft. square filters of the pressure type.

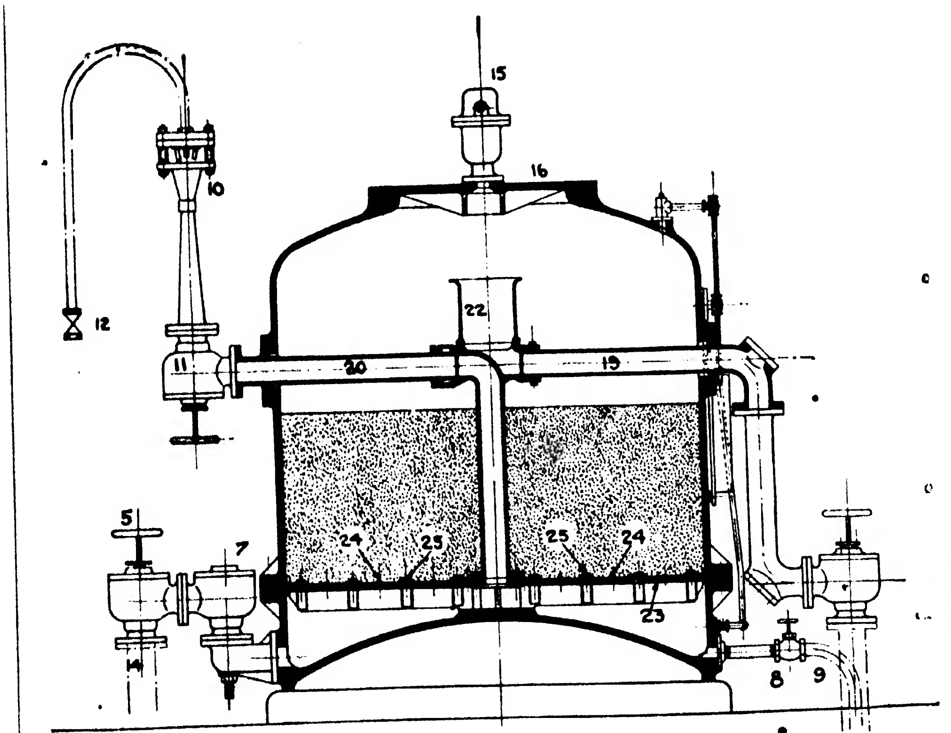
The filters were installed in time for the summer season of 1922, and the same water was used in the swimming baths throughout that period, viz., from the 1st April to the 15th October, with the addition of a few thousand gallons during the season to make up for splashing and natural evaporation. At the end of the season tests were carried out on samples taken from it, and the analyst's report concludes as follows: "The figures generally on this water show it to be of a standard of purity that is not exceeded by many supplies used for drinking purposes."

The saving effected in water supplies alone amounted to 10,000,000 gallons. The charge for water for bathing purposes in this case was 9d. per 1,000 gallons, so that the total reduction in costs for this item was £375.

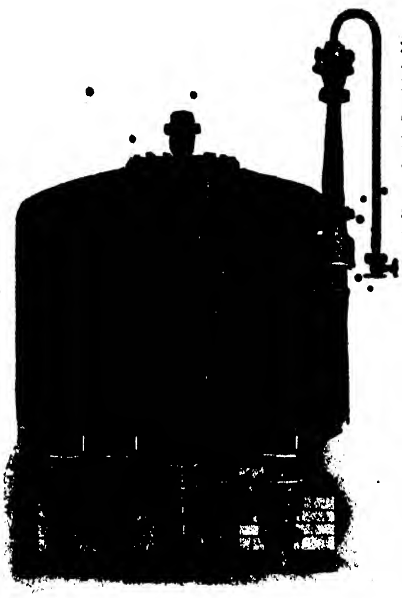
Figures taken out for fuel expenses showed that 70 tons of coal less than in previous years were consumed, and on a basis of 30s. per ton, this item accounted for a reduction of £105 in working expenses.

Against this has to be set the expenditure on electricity necessary to drive the pump used for working the filters, and this will vary with the different districts in which it is to be employed.

On the question of labour, no actual reduction in the number of the sta



Vertical Cylindrical Filter made of Cast Iron



The "Torrent" Patent Filter

was made, but it is important to note that while the operatives were previously much overworked, the duties involved are now comfortably within their power. It is calculated that the actual difference in this respect under other conditions would have amounted to the wages of at least one man.

There remains, however, one further consideration, and it will be interesting to watch developments. One of the chief obstacles to the successful management of public baths in the past has been the difficulty of ensuring a reliable daily standard of cleanliness in the water, and the patronage has undoubtedly been adversely affected in consequence. The results now achieved by the filtration plant referred to above should, however, produce a change in this.

The certainty of finding pure, clean water must prove a very great attraction to all classes, who will no doubt seek relief in the baths from the fatiguing effects of the sweltering summer sun. Once started, the example of patrons will be followed by relatives and friends, and, with proper management, it would seem as if the revenue is capable of increasing to any figure, limited only by the population and the accommodation of the baths.

The increase in patronage obtained in the case with which we are dealing bears this out, as the following figures show:—

Total bathers.	
1921.	1922.
124,209	134,420

It must be remembered that this increase of almost 10 per cent. took place in a year which was unusually wet and cold. The summer of 1921, on the other hand, was remarkable for the intensity of its heat and drought.

The installation referred to was supplied by the Pulsometer Engineering Co. Ltd., of Reading, and Fig. 1 shows a battery of similar filters. They are of the "Torrent" pressure type, which is made either cylindrical or square, to suit the space available, the latter being specially convenient for sites to which the filter has to be brought in parts, *e.g.*, into an existing building through ordinary doors.

A strainer plate near the bottom of the filter casing carries a layer of filtering medium, and the unfiltered water admitted to the upper part of the filter percolates through this. The matter in suspension is retained, and the water reaches the space below the strainer plate in a clear and bright condition. This space is connected to the filtered water main.

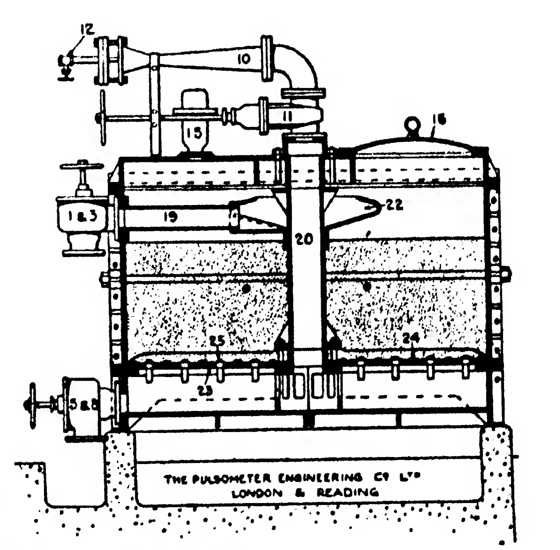
The efficiency of the filtration does not depend so much on the thickness and nature of the filter bed as on the thin film of slimy matter which forms on the upper surface of the filtering medium. It is therefore necessary, when starting the filter for the first time, or when restarting it after cleaning, that the filtered water should be allowed to run to waste for a short time, to enable the surface of the filter bed to get into condition before the water passes into the filtered water main.

The cleaning of the filter is effected by means of air agitation and a reverse flow of filtered water. If there is sufficient pressure in the filtered water main, say equal to 10 to 15 feet head, a reverse flow from the filtered water main can be used, but if there is not sufficient head in this main, or if the filtered water reservoir is below the level of the filter, it is necessary to employ a centrifugal pump to force the washing water through the filter.

In the present instance this was the method adopted, and a Pulsometer A5 type centrifugal was installed, capable of delivering 400 gallons of water per minute against a head of 30 feet when running at 1,000/1,100 r.p.m.

The air agitation is effected by means of a separate system of air nozzles in the strainer plate, through which the air is equally distributed over the whole area of the filter bed. The air nozzles being entirely separate from the strainers, make it possible to use the air simultaneously with the reverse flow of water during the process of cleaning, if found desirable.

The air causes a violent ebullition in the filter, and has the effect of raising the filtering medium, so that



Square Filter made of Cast Iron

the various particles are free to move, and in knocking against one another dislodge all the matter which adheres to their surface. Whilst the air agitation is going on, an upward flow of water carries away through the wash-out pipe the impurities which have been dislodged by the action of the air.

When necessary, a patent wash-water regulating valve may be fitted to limit the rate of the upward flow of water, and to prevent the filtering medium from being carried away with the impurities through the wash-out pipe.

This system of cleaning effects a considerable saving in the amount of wash-water used as compared with that necessary when water only, or water and mechanical agitators, are used. The process of cleaning is carried on until the water coming out of the wash-out pipe is clean. The time to clean the filter may be from 10 to 20 minutes, depending on the nature of the water and time the filter has been at work sincel ast cleaning.

A differential gauge is fitted to show the head lost in the filter. This gauge gives an indication of when the filter requires cleaning, because the difference in pressure between the top and the bottom of the filter increases as the impurities accumulate on the filtering medium.

The aeration plant in the case above referred to consisted of an aerator tank complete with water gauge thermometer, relief valve, etc., in conjunction with a water jacketed air compressor capable of displacing 10 cubic feet of free air per minute against a pressure of 6½ lb. per square inch at 3,000 r.p.m. The latter is driven by belt from the circulating pump coupling formed as a pulley.

The compressed air main is carried above the filter, so that there is no risk of its becoming water-logged, which might cause obstruction to the passage of the air. When steam is available, a steam blower may be used for supplying the compressed air, but if steam is not available, a small air compressor may be driven by a gas or oil engine or electric motor, or, if convenient, by water power from the main.

The addition of a little chlorine to the water keeps it at all times bacteriologically pure.

Several installations similar to the above have now been erected in England, with equally satisfactory results, and other city corporations and baths authorities seem likely to follow this example in the near future.

With these results before them, and the fact that modern filters are not expensive, there would appear to be no reason why every town and city, at least, in the United Kingdom, should not be equipped with public baths.

Clean water day is always a popular day, and if every day is made a clean water day, the receipts from admission charges must increase considerably. This, taken into conjunction with the figures and facts given at the beginning of this article, would appear to show that public baths could be made to pay their way.

The resulting increase in healthy vigour and action on the part of the population, and the development of indulgence in healthy pastime would be a great asset, not only to the locality concerned, but to the nation at large. General welfare and prosperity would receive an appreciable fillip.

Six "Torrent" Patent Pressure Filters (40,000 gallons per hour)

ERRATUM

In our April issue, in an article on "Engineering in Bacon Factories," in speaking of sewage disposal, we erroneously referred to a system installed by Messrs. Tuke & Bell Ltd., London. Instead of "Coke filters" we should have used the words "Aerobic filters," as these filters are not filled with coke, but with vitrified furnace clinker, coke being an unsuitable material.

Draw-out Oil Immersed Flame-proof Switchgear

An interesting account of the draw-out oil immersed flame-proof switchgear manufactured by the General Electric Co. Ltd., to whom we are indebted for the particulars and illustrations.

WE have recently received from the General Electric Co. Ltd., a copy of their Technical Description No. 235, which describes, with the aid of a large number of detailed illustrations, the various features of the draw-out oil immersed flame-proof switchgear, which is manufactured at their Witton Works. It is particularly interesting to note the very wide application of this gear, as by means of various switches, instruments, and other accessories, it is possible to arrange either for a pillar for the control of a single low tension circuit, or, if necessary, a large high tension switchboard for controlling any extensive electrical system.

While designed primarily for use in collieries and mines, this switchgear is equally serviceable in steel works, dockyards, flour mills, and any other undertakings which come within the broad classification of the heavy industries.

The highest degree of safety has been ensured quite apart from the protection given by the flame-proof construction. This is attained by the draw-out feature and the system of mechanical interlocks. If the oil switch carriage is withdrawn, all current carrying parts are dead, and inspection can readily be carried out, the simplicity of design rendering all parts of the gear easily accessible.

The oil switch, busbar chambers, instrument transformer chambers, and other main constructional parts of the gear are mounted on a framework pedestal. The main body of the oil switch is fitted on a sliding carriage which runs easily on slide rails mounted on the top of the main pedestal (Fig. 1). Connection from the oil switch to the busbars is by means of a special wedge type of fixed contact and self-aligning type of moving plug contact. The fixed isolating contact is embodied in a porcelain insulator in the smaller sizes; in larger sizes Bakelite bushings are used. A single contact is used for smaller sizes, but above 300 amps. two contacts per phase are provided. Details of these contacts are clearly shown in Figs. 2 and 3. Particular attention is directed to the wedge contact, as in conjunction with the embracing plug contact on the oil switch a very firm and reliable contact is assured.

The normal travel of the oil switch on the sliding carriage allows a safe clearance break between these isolating contacts when the carriage is withdrawn. The travel of the carriage is limited by lugs on the sides of the switch. These lugs slide over spindles fitted with pins which act as stops. This detail is clearly seen in Fig. 4. The removal of the pins enables the switch to be taken right away from the framework, should this be necessary. A cover is provided for enclosing the busbar contacts when the switch is thus removed. This cover is seen below the oil switch in Fig. 5, and in position over the contacts in Fig. 6. It is provided with wide machined flame-proof flanges.

The various positions available for chambers for instruments and instrument transformers will be dealt with later.

The busbars are contained in cast-iron chambers, which form an integral part of the framework. Suitable lengths of bar are supplied to form a continuous busbar system for any number of units. Strip connections are taken from the busbars to the stems of the isolating contacts.

In addition to the back cover of the busbar chamber, side and top inspection covers are provided where cable boxes are not fitted.

The oil switch is of the free handle type, so that it cannot be held closed against a short circuit or against a low voltage. It is operated by a side lever normally between the adjacent bodies of the switches. (See Fig. 5.) The lever actuates a toggle mechanism which is of steel construction throughout.

A long double break is provided on each phase, and all clearances are on a very liberal basis, which fully complies with the B.E.S.A. Specification. The speed of break is extremely rapid, as evidenced by the curve in Fig. 7. This curve shows the travel of the mechanism; as there is a double break in each phase the current is actually ruptured at double the speed shown by the curve.

The fixed contacts are of the renewable finger type, being secured to metal blocks held in substantial porcelain insulators. The roving contacts are of high conductivity drawn copper, in wedge form, insulated from the operated rods by Bakelite. In addition to the main contacts, renewable auxiliary arcing contacts of the finger type are provided to prevent burning of the circuit contacts. The detail of the contacts and contact insulation is made clear in Fig. 8 Attention is called to the exceptional length of the auxiliary arcing contacts, which allows a high speed of break to be obtained before the circuit is ruptured. This is illustrated in Fig. 7.

The tank is lined with three-ply birch. A further reference to Fig. 8 shows how the tank is divided into sections for each phase. An oil space is left between the lining and the tank. This increases the breaking capacity of the switch, as on the rupture of a short circuit it prevents the gases, which are of a lower dielectric strength than oil, from bridging across the space between contacts and tank. The divisions are also of three-ply birch. Each tank is fitted with an oil level indicator. For lowering the tank for inspection purposes a tank lowering frame is provided. This device is shown in operation in Fig. 9.

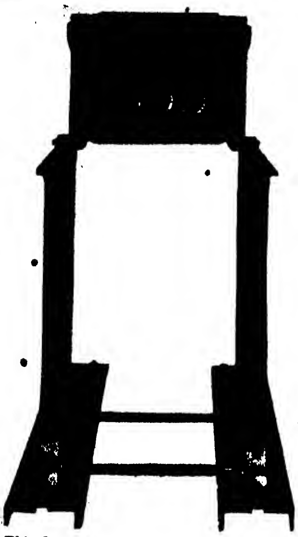


Fig. 1

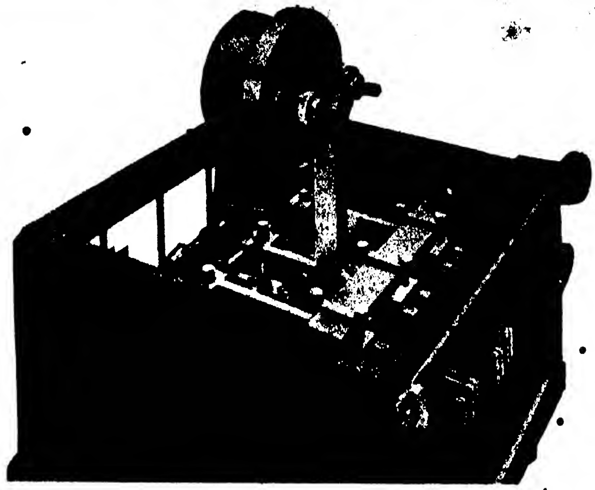


Fig 12

Fig. 3

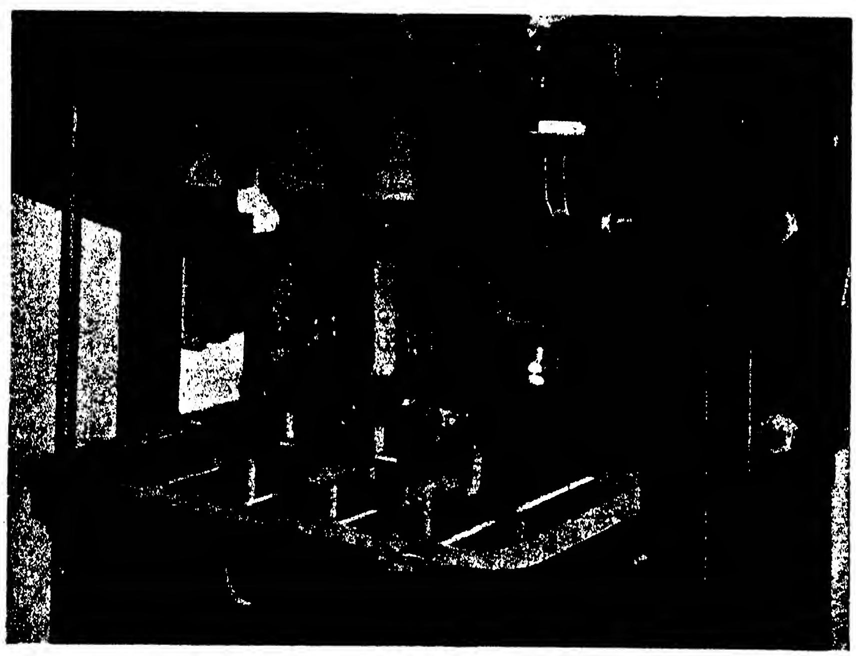


Fig. 8

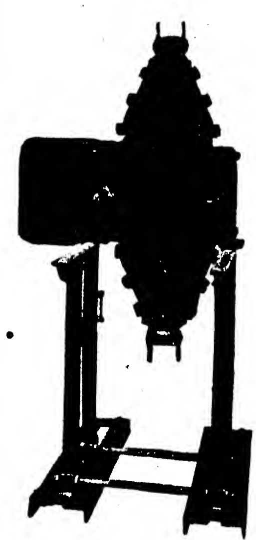


Fig. 6

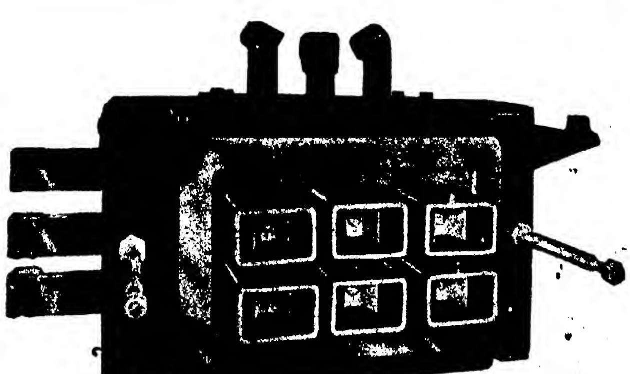


Fig. 2

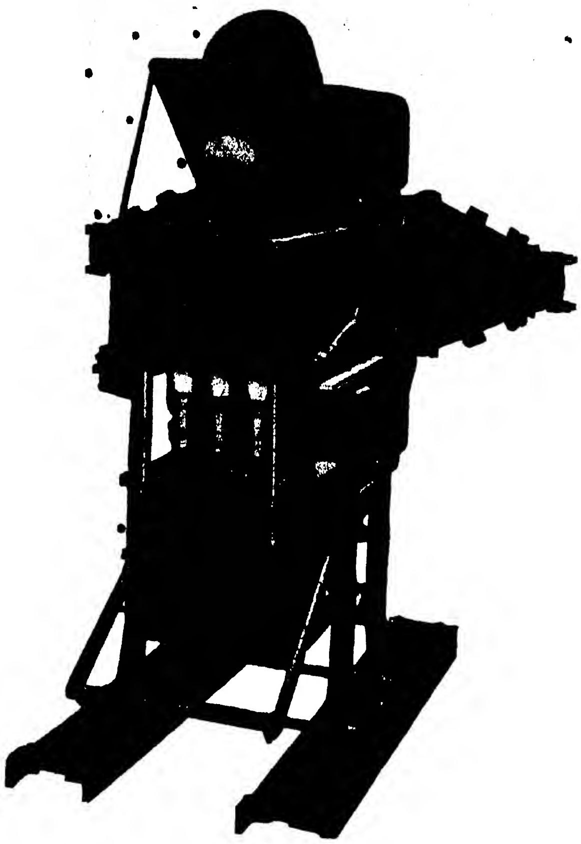


Fig. 9

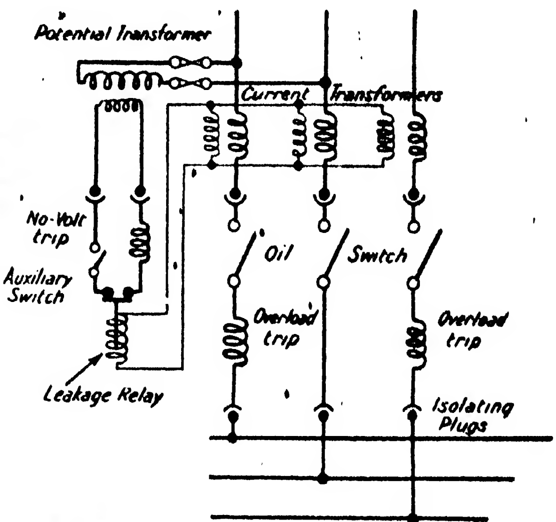


Fig. 10

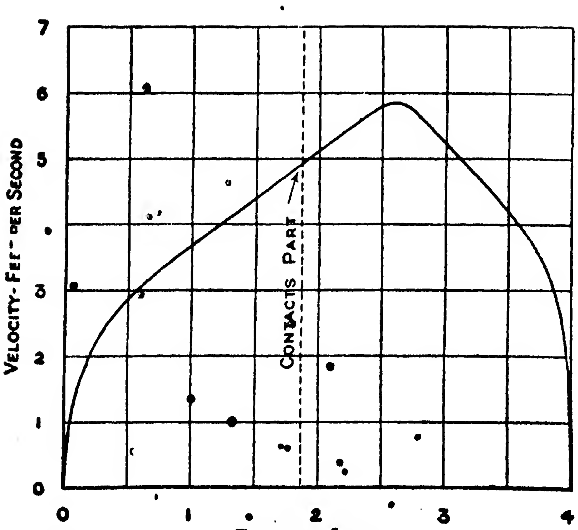


Fig. 7

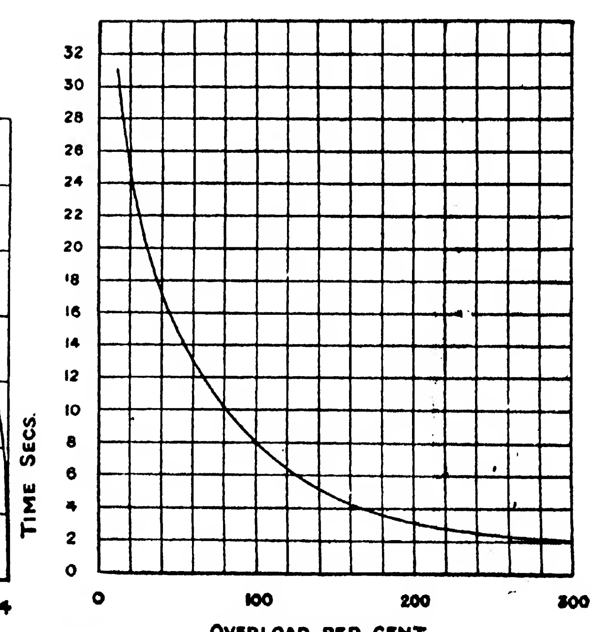


Fig. 11

Any class of protective device can be used in connection with these units, such as :—(1) overload trip coils, (2) no-voltage release, (3) leakage protection, (4) reverse protection, and (5) the usual cable protection systems.

The leakage protection mentioned above is effected by means of the relay shown in position in the oil switch case in Fig. 9. Its use on circuits is illustrated by the diagram of connections (Fig. 10). Three series transformers are required. These are housed in a compartment attached to the busbar chamber. When a leak occurs, the circuit becomes unbalanced, and directly the out of balance current exceeds a certain predetermined value it operates the low voltage tripping attachment through the medium of the relay. A commonly adopted maximum value for the leakage current is five per cent. of normal load.

An adjustable time lag can be incorporated with the overload release mechanism, in conjunction with instantaneous low voltage protection, and with instantaneous leakage protecton. Characteristic curves are reproduced in Fig. 11 showing the duration of the overload tripping delay.

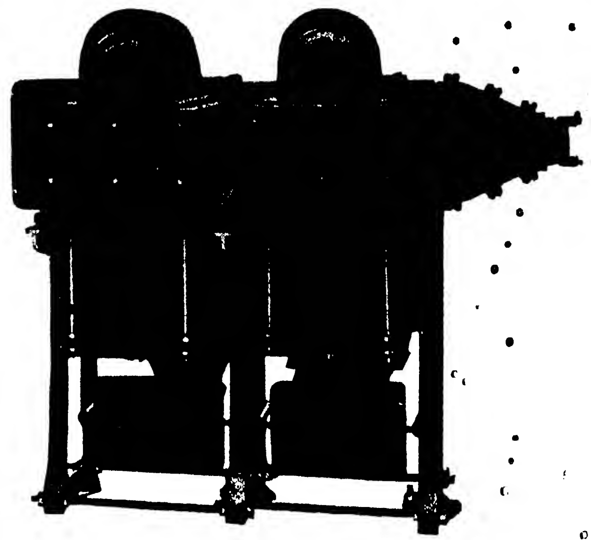


Fig. 5

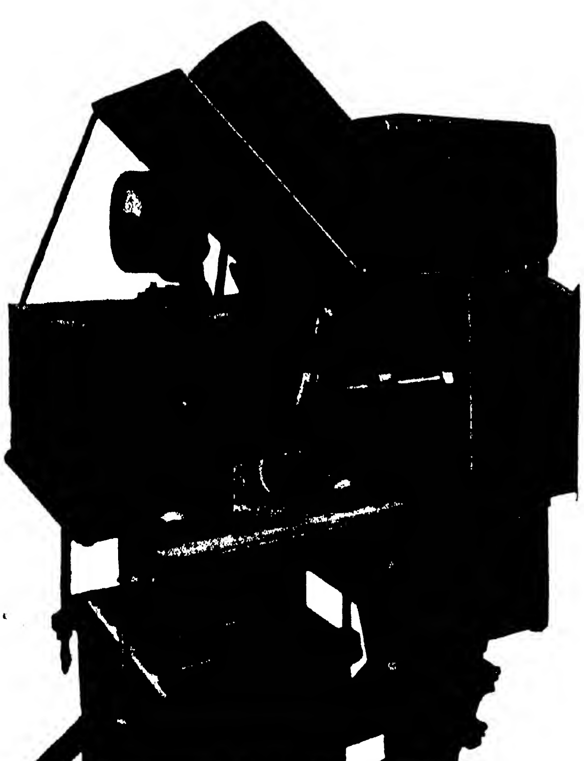


Fig. 4.

A complete system of interlocks, to ensure safety to the operator, and to comply with the requirements of the Coal Mines Regulations, is applied to this gear. These interlocks are clearly shown in Fig. 4.

The switch carriage is normally locked in position either withdrawn or in contact by an automatic bolt at the right-hand side of the switch carriage, and directly below the operating handle. This bolt may only be released while the switch contacts are fully open. The switch contacts may not be closed while the carriage is in an intermediate position, but may be closed for inspection of the mechanism, contacts, etc., when the carriage is *fully withdrawn and locked.* The carriage cannot be accidentally pushed back into contact with the live isolating plug contacts, nor can it be pushed back with the circuit contacts closed.

The oil tank is interlocked by means of lugs which slide in channels in the pedestal sides, and may not be lowered unless the carriage is fully withdrawn. The tank must be replaced before the carriage can be returned.

The switch covers may only be opened when the carriage is fully withdrawn, and must be reclosed before the carriage can be returned.

In the great majority of instances it is desirable that an ammeter should be included in each circuit controlled. The ammeter is mounted over the oil switch body and protected with a hood as indicated in various of the illustrations. The method of fixing

in smaller sizes is shown in Fig. 9, and for the larger sizes in Fig. 12.

The necessary instrument transformers are accommodated in separate cases which are mounted in varying positions as convenient.

All the usual standard types of cable box, armour glands, etc., can be fitted, and special cable boxes are supplied if necessary.

One very interesting adaptation of this gear is that in which two power units and lighting unit are combined. The transformer for the lighting voltage is bolted to the bottom of the busbar case, thus making a thoroughly neat arrangement.

An interesting variation of this gear is the use of an oil immersed draw-out Star Delta starter instead of the oil switch.

It should be noted, in conclusion, that this gear is suitable equally for A.C. or for D.C. circuits. At the present time three standard sizes are available covering voltages from 660 to 3,300, and currents from 800 to 100 amperes.

Uses of Reinforced Concrete

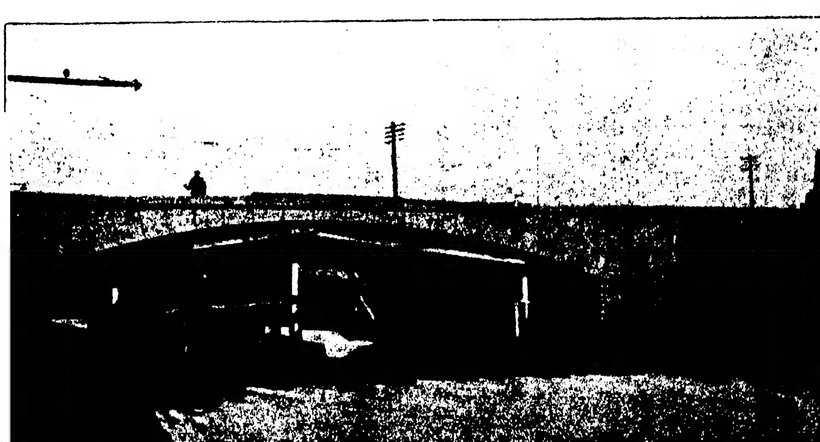
This article provides some interesting examples of the application of reinforced concrete construction to modern engineering requirements.

THE rapid developments which have taken place during recent years in the application of reinforced concrete appear to have given a popular impression that this method of construction is a new and modern invention. This, however, is not the case, as there is evidence that the ancient Romans were acquainted with the principles involved, and used reinforced bars in their famous concrete. The Roman concrete, however, was composed of lime and volcanic scorial, and the reinforcements used were of bronze or iron bars. This early history is very instructive to us to-day, because of the fact that the iron bars used, after having been embedded for 2,000 years, have been found to be in good condition, a fact which bears out the experience of more recent times.

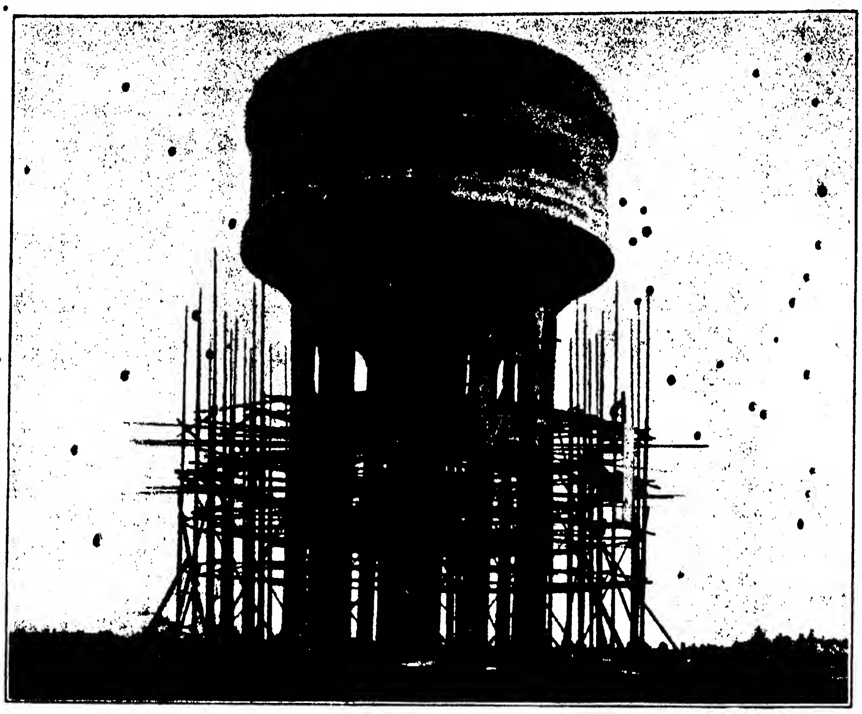
There are many examples still in existence of ancient concrete work, and its ability to withstand the ravages of time, and when it is remembered that the mortar used was inferior to our present-day Portland cement, it seems to show very clearly that reinforced concrete is to play an increasingly important part in the future of all constructional work. It is common knowledge that we are using this method of construction for many of our large buildings, and a recent example of constructional work is the new England lawn tennis stand at Wimbledon. Except for the doors, window frames, seats, and roof, this huge structure, with its accommodation for 14,000 spectators, covering an area of 46,500 square feet, and containing some three miles of seats, is built entirely of reinforced concrete. The exterior of this structure has no ornamentation except that formed by the concrete itself. Nevertheless, the finished building has a very pleasing and business-like appearance.

Railway Trucks

Another recent example of special application is the use of reinforced concrete for the building of railway trucks. Recent experiments carried out in Germany with railway trucks of this construction show that they are capable of resisting severe shocks. It is on record that a fifteen-ton concrete truck was run at the rate of twelve miles an hour against a buffer stop, and at seventeen miles an hour against a stop block—on both occasions without injury. Still another recent application is the use of hollow concrete poles for the purpose of carrying electric overhead transmis-



Wt. Span Bridge — The British Reinforced Concrete Engineering Co. Ltd.



Water Tower *The British Reinforced Concrete Engineering Co. Ltd.*

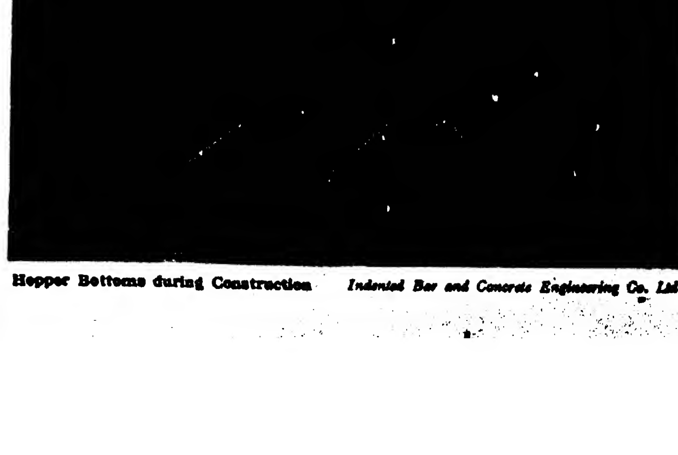
sion lines. Such poles, 60 ft. high, have been erected in Sweden for this purpose. They are hollow, and are made by what is known as the centrifugal process, a method which is now adopted for the manufacture of concrete pipes for drains and other purposes. Incidentally, this method of making pipes is a substitute for the ordinary moulding method, the concrete being placed in a cylindrical tube which is rotated at a high speed, and due to centrifugal force the concrete forms into a hollow pipe, the finished product being a very sound article with both smooth internal and external surfaces.

The use of reinforced concrete for road construction is another very large field in which this material seems destined to play a large and important part, and some interesting work in this direction is being carried out on many main roads.

Concrete and Steel

Considering, now, the general characteristics of our subject, the designation "reinforced concrete," generally adopted by British and American engineers, is not altogether appropriate, because it conveys the idea of concrete reinforced by the addition of steel, and does not indicate that the steel is also reinforced by the concrete. Further, it does not express the combination of two materials possessing equally valuable properties, in such a way as to enable them to act jointly in opposing resistance to external forces. The combination was perhaps better expressed by some of the earlier terms, such as concrete-steel or ferro-concrete, but the main idea to be kept in mind is that the structure is a combination of concrete and steel, and that each of these constituents plays its part in resisting force when forming a member of a structure.

Concrete is a material which the experience of thousands of years has proved to be unrivalled in respect of permanent strength and resistance to the process of natural decay affecting all other structural materials to their ultimate destruction. In structures where the principal effect of the external forces is the development of compression stress, concrete is at its



Hopper Bottoms during Construction *Indented Bar and Concrete Engineering Co. Ltd*

Bines Bridge—Steel for half the width of the Bridge in position

Indented Bar and Concrete Engineering Co. Ltd.

best. Possessing high resistance to compression and capable of effective resistance to tension within reasonable limits, concrete construction is greatly superior to masonry and brickwork, whose stability depends mainly upon the force of gravity, aided to a small extent by the mortar joints.

On the other hand, concrete is not an economical material for forms of construction where the principal effect of the external forces is the development of tensile stress, or the development of compressive and tensile stresses in approximately equal proportions. The reason is that, like cast iron, concrete is considerably weaker in tension than in compression. There is no doubt that the early use of reinforced concrete by the Romans was due to an intelligent recognition of this fact, which, in like manner, accounts for the modern development of the same material.

Although a very new material in comparison with concrete, structural steel is entirely reliable in respect of strength, its only weak point being an extreme susceptibility to corrosive influences. However, when embedded in concrete the steel is effectively protected or reinforced against corrosion, and, thanks to the aid so furnished, is qualified for employment in permanent structures, for the purpose of taking an assigned share in the duty of resisting the stresses developed by the application of external forces. Reinforced concrete may be defined as a combination of concrete and steel, wherein each material is applied so that its distinctive properties are utilised to the best advantage, and is essentially different from steel work merely encased in concrete.

Strength and elasticity are two marked characteristics of reinforced concrete, which also possesses the valuable property of increasing in strength and durability. It also combines the structural advantages of rigidity, impenetrability, impermeability, resistance to fire, and economy both as regards first cost and the elimination of the maintenance charges necessary in the case of all other structural materials.

Other advantages are to be found in the rapidity with which works can be executed, and in the fact that the constituent materials are readily obtainable in all districts, the steel requiring no preliminary workmanship, and the sand and aggregate for the concrete being frequently available

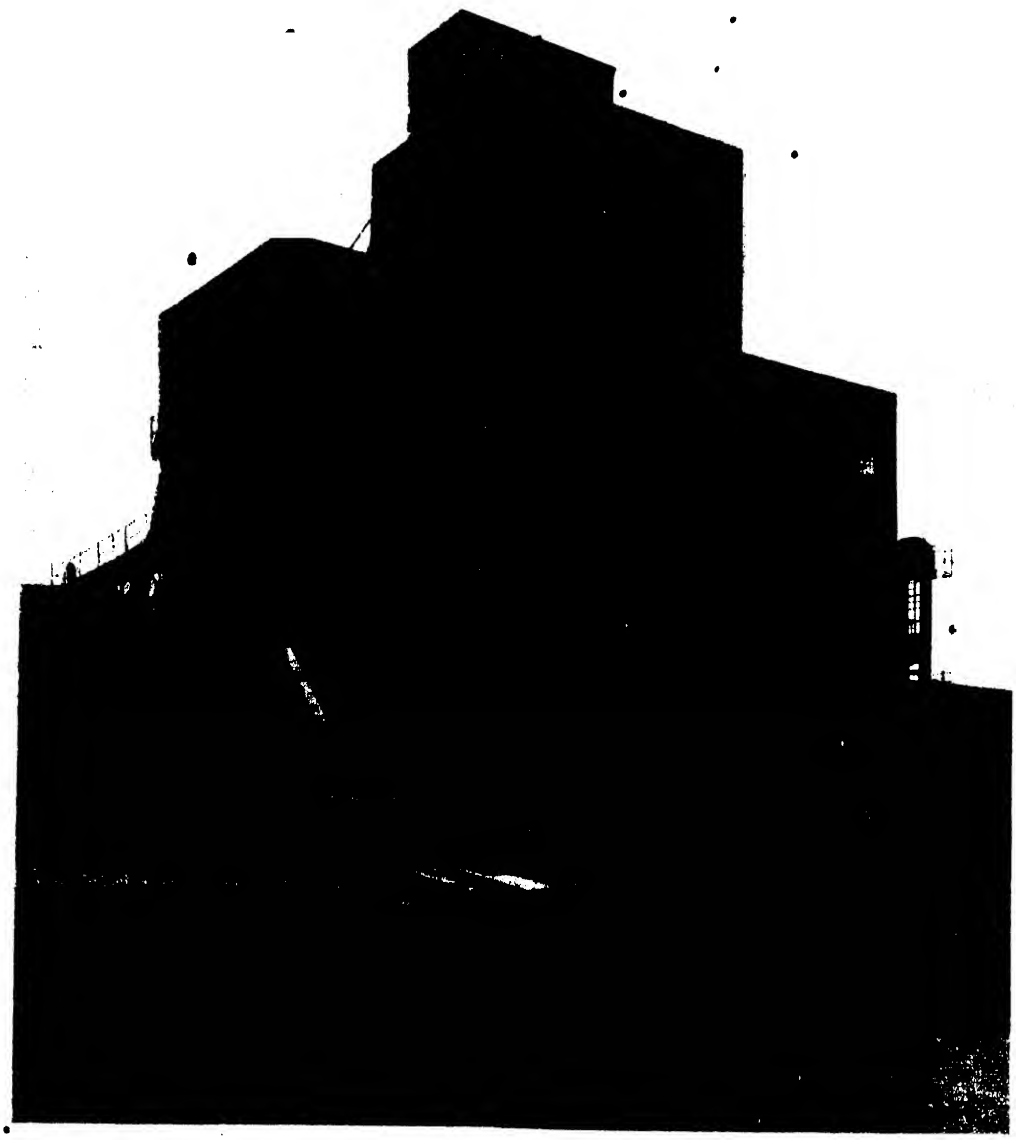
Reinforced Concrete Road

The British Reinforced Concrete Engineering Co. Ltd.

in the vicinity of the works to be executed.

Monolithic Character

Reinforced concrete structures differ from those erected in accordance with ordinary methods in the respect that the entire fabric is of monolithic character, the concrete being in perfect connection throughout, and the steel affording a further assurance of continuity and mutual action between the various members of the structural elements. Therefore, any well-designed and properly built reinforced concrete structure is capable of acting as a single unit in case of emergency, and if unexpected local stresses are suddenly developed by earth movements or any accidental cause, the integrity of the structure is maintained in consequence of the aid which is rendered by contiguous structural members to the part affected.



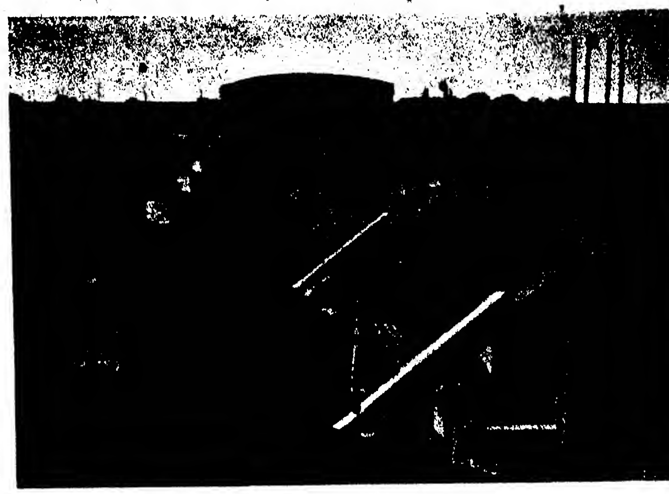
No. 2 Silo, Alexandra Docks, Liverpool — *Indented Bar and Concrete Engineering Co. Ltd.*

Another distinctive feature characterising all reinforced concrete structures is that of lightness or slenderness, in comparison with the heaviness or massiveness of plain concrete, brick, and masonry structures. Thanks to the elastic strength of the combination, the engineer is enabled to depart from the custom of employing material in heavy masses, and to adopt forms of design akin to those found in steel construction. Apart from the gain of interior space in buildings, reservoirs, and structures intended for storage purposes, important economies are effected by this method of design. The saving of material in the superstructure naturally has the effect of reducing the load to be transmitted to the earth, thereby reducing the cost of foundations, and obviating the difficulties which frequently occur in work of the kind.

Constitution of Concrete

Concrete is formed by mixing together fragments of stone or other hard, inert matter with a certain proportion of sand and cement, the latter ingredient forming the binding material which binds the whole into one solid mass. In reinforced concrete work the use of broken stone or gravel is necessary in order to produce concrete of adequate strength and durability, and, for the same reason, Portland cement is employed as the cementitious material, instead of any of the varieties of lime and other cements which are still largely used in ordinary construction.

The grading of the sizes of the individual pieces which form the aggregate is a matter of prime importance. It will be readily understood that in a heap of broken stones each individual stone, say 2 in. in diameter, will form a mass which is not solid, because of the gaps or voids between the stones themselves. If, however, a proportion of smaller stones, graded in sizes to fill these voids, is mixed with the 2 in. stones, then the original heap will more nearly approach a solid mass. To go one step further, and mix the original stones with smaller graded stones, and, in addition, add a proportion of sand, then the resulting heap, if the mixture is properly graded, will approach to the ideal solid mass which is aimed at for a good concrete mixture. Cement is, of course, finally added as the binder, when, after mixing with water, the very fine cement fills up the tiny voids between sand particles, and the sand-cement mixture fills up the voids between the larger stone pieces. All the particles, large and small, should be well coated with sand-cement mixture and cement respectively, and when the cement hardens by a process of chemical reactions, the whole solidifies into a compact, crystalline mass.



Wharf at Kelham. Pre-cast Members Assembled

Indented Bar and Concrete Engineering Co. Ltd.

LOW TEMPERATURE CARBONISATION (*Table referred to on page 591*)

TILMANSTONE (KENT) COAL.
Date received, 2nd May, 1922. Tested 4th May, 1922.

Analysis.

Percentage contents of—	As received.	As dried.
Volatile matter	26.73	27.12
Coke	71.84	72.88
Ash	14.18	14.39
Fixed Carbon	57.66	58.49
Free Moisture	—	—
Hygroscopic Moisture	1.43	—

Thermal Values—	Available as received.	As dried.
Calorific value	12,554	13,150 B.Th.U's.
Carbon equivalent	—	12,456 ,,
Evaporative power	12.99	13.61 lb. of water from and at 212° F. per lb. of coal.

LOW TEMPERATURE FUEL FROM ABOVE.

Analysis.

Percentage contents of—	As received.	As dried.
Volatile Matter	8.73	8.84
Coke	90.02	91.16
Ash	17.82	18.05
Fixed Carbon	72.20	73.11
Free Moisture	—	—
Hygroscopic Moisture	1.25	—

Thermal Values—	Available as received.	As dried.
Calorific value	12,034	12,600 B.Th.U's.
Carbon equivalent	—	11,924 ,,
Evaporative power	12.45	13.04 lb. of water from and at 212° F. per lb. of coal.

CHISLET (KENT) COAL.
Date received, 2nd May, 1922. Tested 4th May, 1922.

Analysis.

Percentage contents of—	As received.	As dried.
Volatile Matter	29.35	28.92
Coke	69.06	70.18
Ash	12.68	12.89
Fixed Carbon	56.38	57.29
Free Moisture	—	—
Hygroscopic Moisture	1.59	—
Nitrogen	1.02	1.04

Thermal Values—	Available as received.	As dried.
Calorific value	12,719	13,355 B.Th.U's.
Carbon equivalent	—	12,675 ,,
Evaporative power	13.17	13.82 lb. of water from and at 212° F. per lb. of coal.

LOW TEMPERATURE FUEL FROM ABOVE.

Analysis.

Percentage contents of—	As received.	As dried.
Volatile Matter	10.59	10.75
Coke	87.92	89.25
Ash	14.62	14.84
Fixed Carbon	73.30	74.41
Free Moisture	—	—
Hygroscopic Moisture	1.49	—

Thermal Values—	Available as received.	As dried.
Calorific value	12,546	13,075 B.Th.U's.
Carbon equivalent	—	12,391 ,,
Evaporative power	12.99	13.53 lb. of water from and at 212° F. per lb. of coal.

Air Filtration for Industrial Purposes

A subject which covers a wide industrial field, and one which not only promises to secure the health of the worker, but also to ensure important economies in the process of manufacture.

THE subject of air filtration covers a very wide industrial field. For the needs of human life it is necessary that the air we breathe should be of a sufficient degree of purity, in addition to having the correct degree of humidity. But on the purely manufacturing side of industry the process of filtering air has become a very important one, not only for the purpose of removing impurities, but also for the actual recovery of such impurities. The word "impurity" is not strictly a correct term to use under these circumstances, because useful products are very often recovered, such as material in a fine state of division in cement works, chemical works, flour mills, textile mills, porcelain factories, abrasive wheel works, and so forth. Another branch of what may be termed air purification is that in which combustible gas is made suitable for use in gas engine cylinders or for burning under steam boilers.

In all these different applications, however, the principles involved in the actual filtration process are very similar, and may be broadly divided into two classes; firstly, those employing fabric or similar fine materials which act as a positive dry filtering medium, and secondly the wet process, when the air to be filtered passes through a fine water spray, of which there are many different arrangements.

The question of the filtration of air for ordinary mill or factory use immediately overlaps with the problem of heating and ventilation. The trend of development in modern factory practice is to instal mechanical means for supplying the air necessary for the purpose of ventilation; and this system lends itself admirably to heating the mill, as it is only a matter of passing the incoming air over heated steam-pipes in order to raise it to the temperature required in the mill atmosphere. This system has the further great advantage that it is a simple matter to give the incoming air the correct degree of humidity before allowing it to enter the mill building. Incidentally, it may be recorded here that leading authorities appear to agree that the correct degree of humidity in the air we breathe is just as important as the minimum CO_2 content, and, in fact, some authorities go so far as to say that it is even more important.

The Water Spray

This brings us to the point of filtration. The air is humidified by passing through a water spray, and during this process the impurities held in suspension are washed out. The washing or filtering process may take place by passing the incoming air over wet fabric or other wettened surface in any convenient form, or by passing through a water spray. The latter method is now generally adopted as a standard practice, and the general arrangement of the apparatus is as follows. A chamber of suitable dimensions is arranged with an inlet for the incoming air, and at the outlet is fixed a fan to create the necessary suction and draw the air through the apparatus. The interior of the chamber is arranged with a large number of water nozzles, which are capable of discharging water sprays in a very finely divided state. The result, when all of these sprays are in operation, is completely to fill the chamber with a cloud of very fine water mist. The incoming air passing through this water-cloud is very efficiently washed of its impurities, and before leaving the chamber the direction of flow is generally diverted by means of suitable baffle plates, for the purpose of removing any solid matter which may remain before the filtered air reaches the fan and passes out of the apparatus.

Sturtevant Water Spray Air Filters

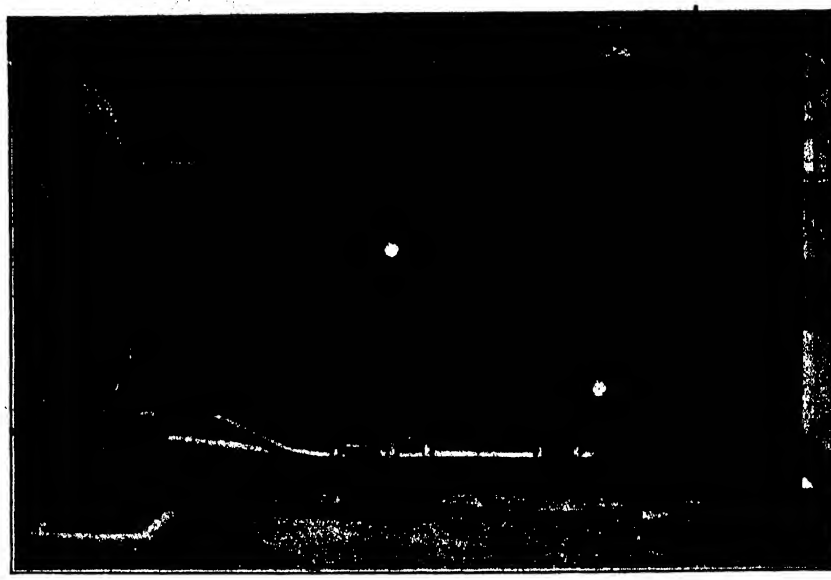
These plants comprise a rectangular passage, or mist chamber, open at the ends and erected over a shallow tank which is usually 18 in. deep. In the chamber is fitted a nest of sprayers attached to vertical pipes by means of which a water mist is directed and

Motor Driven Fan — Sturtevant Engineering Co. Ltd.

mixed with the air passing horizontally through the apparatus. The inlet end of the chamber is usually provided with a set of vertical louvres, and in the outlet end a similar set of more elaborate louvres, known as eliminator plates, are fitted.

The circulation of the water to the sprayers is maintained by means of a small motor-driven centrifugal pump, which, taking the water from the tank at the base of the apparatus, returns it to the sprayers in the mist chamber.

A portion of the eliminator plates is kept wet by means of a battery of sprayers arranged under the roof of the apparatus, and fed by a by-pass pipe leading from the delivery side of the pump.



Heating Chamber — Sturtevant Engineering Co. Ltd.

The apparatus functions by the intimate mixing of the air and water mist which is driven forward on to the wetted surfaces of the eliminator plates, where both the dirt and the free moisture are carried down into the tank. When operating correctly, the portions of the eliminators where the air leaves the apparatus should be quite dry.

It is the usual practice to fix on the outlet end a conical connection approximately 3 ft. long, to ensure an equal air velocity between eliminators.

The water from the tank is drawn through suction screens of ample area, the design of which varies according to circumstances, but they are usually rectangular, and slide in grooves from which they can be easily withdrawn for cleaning. As an additional safeguard, a pot strainer is placed on the delivery pipe consisting of a copper gauze pot inside a cylindrical casting.

A stand pipe is provided on the bottom of the tank to maintain the water at the correct working level. This stand pipe is a special fitting designed for the apparatus, and so arranged on a central spindle that it can, when required, be raised 1½ in. from the bottom of the tank, thus affording an opening for cleaning.

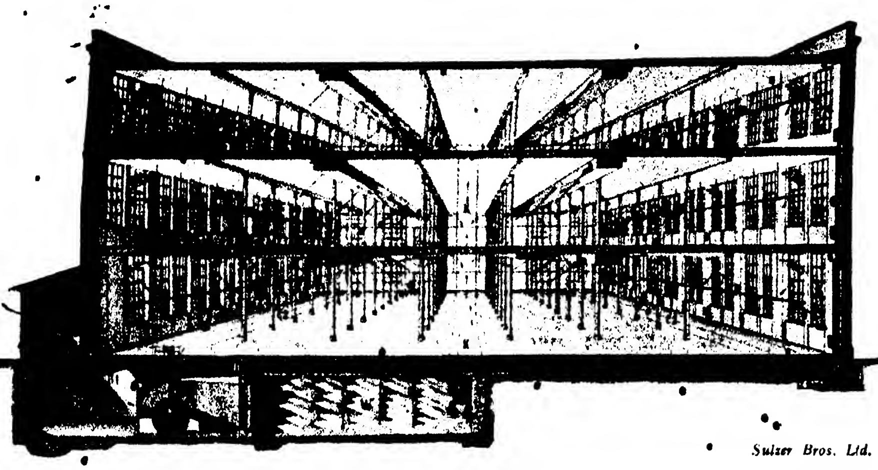
The water service to the filter is provided through two valves mounted on one fitting. The larger valve serves for filling when the apparatus is charged, and the smaller valve, which is usually kept open, is connected to a ball valve in order to make good any wastage that occurs through evaporation or other reasons.

We will now consider in some detail the dry process of filtration for different industrial processes. It will be readily understood that the atmosphere, for example, of a flour mill, or cement works, or the turning shop of an abrasive wheel factory, soon becomes laden with fine dust from these different processes. In some cases, such as in a flour mill, this dust-laden atmosphere is extremely dangerous, and readily forms an explosive mixture with the air. In any case such dust-laden atmosphere is not fit to breathe, while the dust itself is often worth recovering as an actual commercial proposition.

To recover this fine dust by the dry process, some form of fabric filter bag is generally used, and the general arrangement of the plant follows along the following lines : The filter bags are mounted within a casing, which is, of course, sealed to the outside atmosphere, divided into compartments, each of which carries a nest of filter bags in the form of long fabric tubes. The top ends of these tubes are closed, but the bottom ends open into a compartment chamber below. From this chamber the incoming dust-ladened air enters the inside of the fabric tubes, and, passing through the fabric walls, drops its dust content, which either clings to the inside wall of the tubes, or drops down into the chamber below. The filtered air passes through its particular compartment and away to the pure air conduit.

The fabric tubes, however, very soon become clogged up with the dust, which clings to their inner walls, and therefore some method must be used to remove this dust if the apparatus is to work efficiently and continuously. This cleansing process is usually carried out in a very effective manner. Normally the fan draws the dust-laden air through the filter tubes, but a suitable arrangement of valves enables the fan to draw, when required, pure air from the atmosphere through these tubes in the reverse direction, and so push or blow the dust off the inside surface. While this reverse current of cleansing air is passing, the tubes are agitated or shaken in a vertical direction, and the result of this combined action of shaking and the passage of a reversed air current is very efficiently to remove the dust. The process takes place quite automatically at regular intervals by means of suitable mechanism which is mounted on the filter casing, and the arrangement is such that one compartment is being cleared while another is filtering the incoming dust-laden air, so that the apparatus works continuously.

There are many applications of this general principle, and these vary only in detail in accordance with any special arrangement of the industry. In the case of removing and collecting emery dust, for example, the dust-laden air would first enter a cyclone and chamber arranged with baffle plates, in order to remove the heavier particles before the air reached the filter bags. Another example is the case of hot gases from certain metallurgical furnaces, when the gases are first cooled before entering the filter tubes.



Sulzer Bros. Ltd.

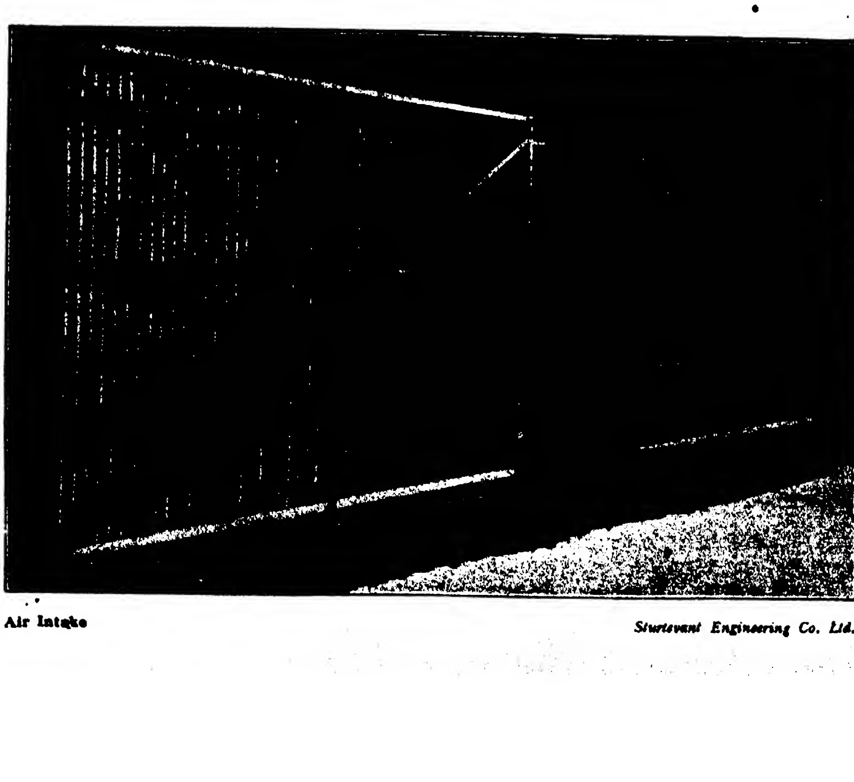
F. Air Intake	C. Return Air Duct	R. Mixing Dampers	K. Distribution Duct
O. Vent Openings	P. Heating Coils	H. Heater Sections	W. Air Conditioning Apparatus

The filter-bag principle was long in use for filtering blastfurnace gas before it was suggested to utilise the latter in gas-engine cylinders. In this difficult branch of industrial filtration the filtering medium takes many different forms, particularly for the cleaning of producer gas, in which it is the general practice to use both the wet and dry methods. The crude gas first passes through a vessel filled with coke or other suitable medium, which is kept in a wet state by means of a water spray, when the gas passing up through the wet coke is relieved of its solid contents by a washing and scrubbing process. After leaving the wet scrubber or purifier the gas is passed to a dry scrubber consisting of a vessel filled with a dry filtering medium such as sawdust, wood shavings, or similar material, which removes the moisture from the gas collected in passing through the wet coke scrubber.

Another form of air filter is that in which oil is used as the filtering medium. This consists of a casing divided into compartments which are filled with a very large number of thin coppered steel rings, which are kept coated with a special thick oil. The impurities in the air passing through the filter cling to the oiled-coated surface of the thin rings, the purified air passing on.

One of the more recent applications of air filters is their use in modern power stations. The present-day large turbo-alternators require a regular supply of cool, clean air through the body of the machine. It is necessary that this air be clean, otherwise the small ducts through the windings would soon be clogged up, and it should be cool in order that the output of the generator may be maintained without rise of temperature. It is usual to draw the air through a filter in the basement of the turbine-house, and after passing through the alternator the air is allowed to enter the room by way of the top of the alternator casing. The air filter for this special purpose is generally a combination of the wet

(*Continued on page* 591.)



Air Intake

Sturtevant Engineering Co. Ltd.

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE :: :: :: :: DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS :: :: :: ::

The Problems of the Engine Indicator

BY LOUGHNAN PENDRED, M.I.MECH.E.

In the following paper, read before the Institution of Mechanical Engineers, London, an instructive survey is made of the fundamental problems of the engine indicator.

SOME members may recall the discussion provoked nearly forty years ago by Osborne Reynolds at the Institution of Civil Engineers, which may be read profitably in the eighty-third volume of the Proceedings of that Institution. The famous professor ventured to assert, and endeavoured to prove by mathematics and by the analysis of experiments made by Mr. Brightmore, and reported on the same occasion, that the steam-engine indicator was a much more fallible instrument than was generally supposed. Many of the great engineers of that day stoutly denied the charges and affirmed their unshaken belief in cards taken by skilled operators. This old paper is referred to now because whatever differences of opinion about the quantitative value of Osborne Reynolds' results may be justified, there can be no question that he examined with his accustomed skill and accuracy all the qualitative faults of indicators and their gear. In the intervening years the matters that he dealt with—the inertia of the parts, the elasticity of the cord, the friction of the pencil, the varying pull of the drum-spring, and last, but not least, the periodicity of free vibration of the spring—have become familiar to every student of engineering. They are still, as they were then, the problems of the indicator, but they have been magnified in importance by the augmentation of pressure and the increase in speed of engines, whilst a new problem has been introduced by the adoption of temperatures far higher than any with which Osborne Reynolds had to deal.

Did time permit it would be not unprofitable to follow the development of the indicator from its invention, by James Watt, and its improvement, by McNaught, through the numerous designers who, step by step, have removed its faults and evolved the beautiful optical indicators of to-day. That course cannot now be followed in detail, but the Council of this Institution has thought that cohesion would be given to this symposium if the nature of the problems which inventors have had to face were placed in broad outline before the meeting.

Inertia.—The greatest of all these problems is in the case of mechanical indicators, the inertia of the piston and the pencil mechanism. It soon became evident that satisfactory diagrams could only be obtained if the stroke of the piston were short. Hence magnifying mechanism had to be employed. It took, and still takes, the form of a lever giving a multiplication of either four or six times. In Gooch's locomotive indicator a plain lever was employed and the pencil in consequence struck a curved line. A correspondingly curved scale had to be used for the measurement of the pressure and to overcome that inconvenience straight line motions of one kind and another came into use. The outstanding characteristic of the different indicators is to be found in the form of straight line motion employed. The object sought is a linkage that can be made extremely light, but robust enough to stand fairly rough handling, and accurate enough to give a substantially straight line through the working portion of the stroke. The famous Richards indicator used the Watt parallel motion. It was followed by the Thompson indicator of 1875, in which the Scott-Russell motion was employed, and by other modifications of linkage—of which the Crosby is the most familiar—and by partly-guided mechanism of the Tabor and Darke form. In each successive case the inventors endeavoured to find a mechanism which, whilst fulfilling the requirements, could be made lighter than that of predecessors. Through the courtesy of the Director of the Science Museum, South Kensington, where a very interesting collection of indicators is preserved, the author has been enabled to show the total weight of all the moving parts with the exception of the springs. The weight of the spring cannot be neglected, and it is usual to take one-half or one-third of it into account. It is needless to point out that the mere weight of the parts does not give us a complete clue to their effect. The parts move in various directions with various accelerations, and have various moments of inertia, each one of which has its own proper effect upon the pencil.

TABLE.

Particulars of Steam-Engine Indicators in the Science Museum, South Kensington.

Date of Invention	Name of Indicator. (Name of Maker.)	Weight of Piston and Rod.		Weight of Linkwork for Parallel Motion.		Weight of Spring.		Scale of Spring.	Piston Area.	Total Weight of Parts receiving Direct Motion.		Remarks.
		gm.	oz.	gm.	oz.	gm.	oz.			gm.	oz.	
About 1800	*Watt's.* (Boulton Watt and Co.)	111	3.88	—	—	34	1.20	1″–1 lb./sq.″ Max. press. reading 3.5 lb./sq.″	1 sq.″	145	5.12	—
1810–20	*McNaught.* (Probably McNaught.)	89	3.14	—	—	71	2.51	1″–4 lb./sq.″ Max. press. reading 5 lb./sq.″	1 sq.″	160	5.65	—
1825–30	(*a*) *McNaught.* (Chadburn Bros.)	55	1.94	—	—	15.5	0.55	1″–20 lb./sq.″ Max. press. 30 lb./sq.″	0.25 sq.″	70.5	2.49	—
,,	(*b*) ,, ,,	42	1.48	Inner spring 25.5	0.90	Extra spring 18.5 +7.0 (reciprocating weight.)	0.90	Inner spring 1″–10.53 lb./sq.″ Ex. sp. combined scale 1″–21.06 lb./sq.″	0.25 sq.″	67.5 Combined scale 93.0	2.38 3.28	Inner spring Max. press. reading 13 lb./sq.″ Combined scale Max. 26 lb./sq.″
,,	(*c*) ,, ,,							—	0.5 sq.″	241	8.52	—
	Similar to (*a*) & (*b*) but larger & main spring in tension above atmospheric instead of in compression.	Details not measured.										
1840	*Hopkinson.* (Hopkinson.)	—	—	Inner spring 6	0.212	Upper spring 15.0 +15.0 (reciprocating weight.)	1.06	Inner spring 1″–10.71 lb./sq.″ Max. press. 15 lb./sq.″ Upper spring combined scale 1″–51.1 lb./sq.″ Max. press. 70 lb./sq.″	0.25 sq.″	100	3.53	—
1862	*Richards.* (Elliott Bros.) "Improved Patent Steam-Engine Indicator."	30.51 Including milled nut fastening to parallel motion links.	1.08	16.02 Ratio tracing point to piston displacement 4 : 1.	0.565	15.72	0.555	1″–8 lb./sq.″ Range 10–15 lb./sq.″	0.5 sq.″	62.25	2.20	Has linkwork for parallel motion & interchangeable springs in various pressure scales.
,,	,, ,, Manufacturer's No. 1004. (Earlier make than above.)	27.63 Including as above.	0.976	12.18 Ratio as above.	0.43	24.1 29.48	0.85 1.04	1″–20 lb./sq.″ 15–47 lb./sq.″ 1″–40 lb./sq.″ 15–110 lb./sq.″	0.5 sq.″	63.91 69.29	2.26 2.45	— —
1878	*Kenyon's.* (Isaac Storey and Sons.)	—	—	20.86 Ratio of tracing point travel to Bourdon Tube displacement 24 : 5.	0.736	—	—	—	Diagram scale given by Bourdon tube 1″–50 lb./sq.″	20.86	0.74	Has Bourdon Pressure Tube instead of piston and spring.
1878	*Tabor.* (John Musgrave and Sons.)	19.63 Including connections to tracing arm.	0.693	2.68 Ratio of displacements 5 : 1.	0.095	22.71 38.80	0.80 1.37	1″–40 lb./sq.″ 1″–100 lb./sq.″	0.5 sq.″	45.02 61.11	1.59 2.16	—
1879	*Darke's.* (Elliott Bros.).	20.38 Including milled nut connection to tracing arm.	0.72	5.31 (Tracing arm) ratio of displacements 4 : 1.	0.187	8.10	0.286	1″–20 lb./sq.″ Range 15–20 lb./sq.″	0.5 sq.″	33.79	1.19	For high-speed engines. Tracer guided by slot (fixed) instead of by linkwork.

TABLE.

*PARTICULARS OF STEAM-ENGINE INDICATORS IN THE SCIENCE MUSEUM, SOUTH KENSINGTON.

Date of Invention	Name of Indicator. (Name of Maker.)	Weight of Piston and Rod.	Weight of Linkwork for Parallel Motion.	Weight of Spring.	Scale of Spring.	Piston Area.	Total Weight of Parts, receiving Direct Motion.	Remarks.
		gm. oz.	gm. oz.	gm. oz.			gm. oz.	
1879–82	*Crosby.* (Crosby Steam Gauge and Valve Co.)	15.23 0.54 including Taper pin connection to linkwork of parallel motion.	3.20 — including a Taper pin not included under Piston, etc. Ratio 6 : 1.	17.69 0.63	1″–10 lb./sq.″	0.5 sq.″	36.12 1.28 — 1.1* — 1.1*	For high-speed engines. Steam } Present Gas } day.
1888	*McInnes-Dobbie.* (Dobbie McInnes, Ltd.) " Improved Form, Large Size, Design No. 1, External Spring."	38.02 1.34	10.10 0.36 Ratio 6 : 1.	14.00 0.494 17.81 3.63 21.92 0.78	1″–16 lb./sq.″ Range. 15–21 lb./sq.″ 1″–40 lb./sq.″ up to 90 lb./sq.″ 1″–80 lb./sq.″ up to 180 lb./sq.″	0.5 sq.″ — — — —	62.12 2.19 65.93 2.33 70.04 2.40	Smaller sizes suitable for high-speed engines were made at the same date as this model, and with lighter parts and internal springs.
1893	*Wayne's.* (Elliott Bros.)	(82.82 2.92) Including semi-rotary piston and spring and rotary shaft on which both are mounted.	Pencil arm and screw fastening to rotary shaft, 9.42 0.333	Included under piston	1″–40 lb./sq.″ Spring in torsion.	Diameter of cylinder 1″, diam. shaft in cyl. ½″. Area of each of the 2 vanes on which pressure acts = (½″ × ¼″) = ⅛″ sq.″	9.42 0.333 + Torque value on *piston, etc.*	No linkwork for parallel motion. Semi-rotary piston and horizontal shaft directly actuating pencil arm.
1894–5	*Simplex.* (Elliot Bros.).	26.53 0.94	About 7.00 0.247 Unable to take adrift as parts riveted together.	16.77 0.59 Half above wt. carried by framework (bow spring).	7 lb./sq.″ above atmospheric pressure of 15 lb./sq.″	0.5 sq.″	41.92 1.48	Ratio of tracing point and piston displacements 4 : 1.
Present	*Casartelli.*	— —	— —	— —	— —	— —	— 1.5* 1.25*	½″ area piston. ¼″ " "

* Supplied by makers.

The analysis of that effect, as may well be imagined, is one of no small intricacy.

Before leaving this very important problem, it should be noted that since, in very high-speed engines, internal-combustion motors particularly, the load is suddenly applied and, what is of great importance, is very rapidly removed, it amounts virtually to a blow, and causes such serious inertia effects by driving the pencil far above its true position, and such violent spring oscillations, that reliable indications at a speed above, say, 300 to 400 r.p.m. are impossible. Another fact of a mechanical nature must also be mentioned. Indicator manufacturers have found it imperative to make hinges bigger, and consequently heavier, to meet increased loads. It is probable that even now there is, after a certain time, enough wear in the joints seriously to affect the area of cards.

Spring Vibration.—Mention has been made of the necessity of reducing the stroke of the piston. This necessity arose from a condition which obtains as well in the optical indicators of to-day as in all mechanical indicators. A long stroke is associated with a long spring, and the period of free vibrations of long springs of suitable dimensions is so great that a wavy line is drawn by the pencil in place of a steady line. But if a short and stiff spring be employed the frequency of vibration becomes so high that within certain limiting speeds, the waves, which are very small, are damped out by the friction of the piston, of the pencil, and of the joints. Osborne Reynolds found that if there were thirty complete oscillations per cycle a fair diagram was drawn. Hence the natural frequency for springs must not be less than thirty for moderate-speed engines; it must be much higher for high-speed engines. In optical indicators of the Hopkinson or Burstall type extremely stiff springs are used, springs, that is, with a natural frequency of something approaching, or even exceeding, 1,000 per second, and with an extremely short stroke. But these instruments are intended for indicating high-speed internal-combustion engines, engines giving impulses to the spring at any rate up to thirty-five per second, and at the same time exerting very high pressures. In disc type indicators, that is in indicators which use a flat metal disc as the spring, the natural frequency is possibly still higher. Such

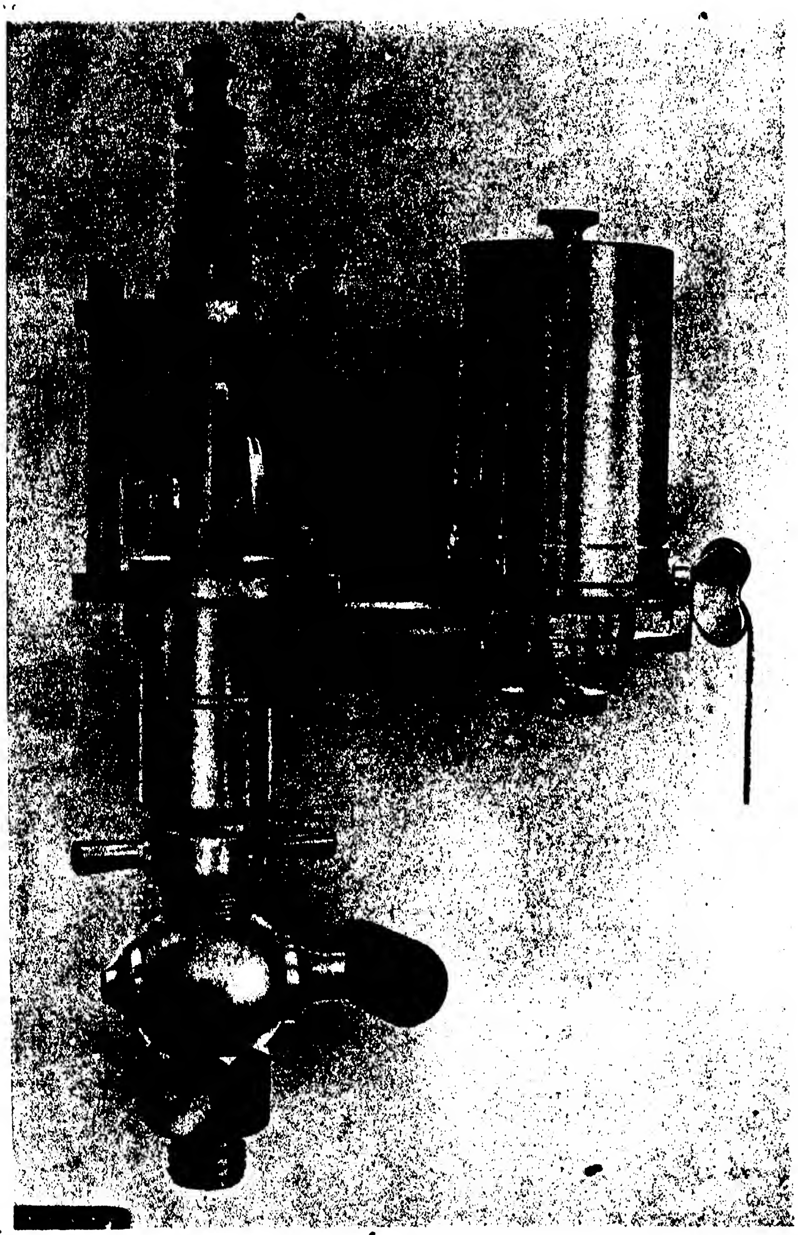
springs have even at speeds up to 1,500 r.p.m. no injurious oscillation; but since they are, when combined with their attachments, appreciably ponderous, their inertia may have a sensible effect when it is recalled that they have to be given their maximum deflections in a minute fraction of a second.

If we assume that combustion is complete when the piston has moved through 15 deg., then in an engine running at 1,800 r.p.m. the maximum deflection must take place in $\frac{1}{720}$ of a second. It may help us to form some sort of a conception of this exceedingly brief period if it is stated that the distance through which a body would fall from rest in that interval of time is no more than $\frac{1}{2700}$ of an inch.

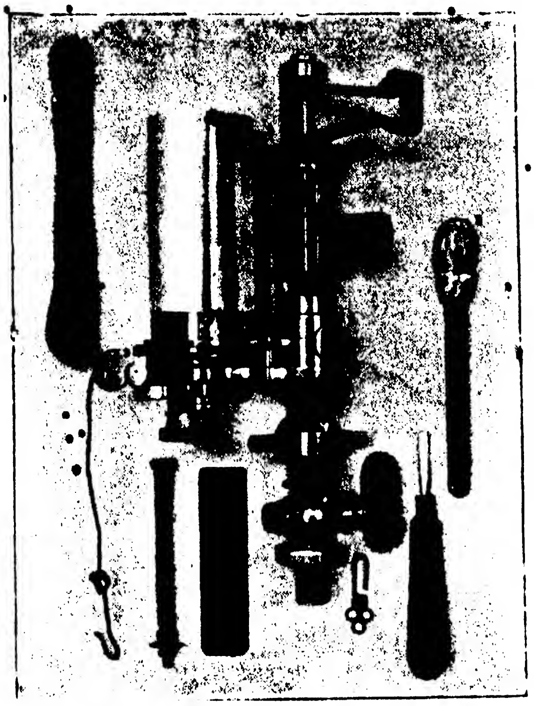
In one indicator, designed by the Royal Aircraft Establishment, the moving portion is made extremely light, and this cause of error or lag should thus be obviated. This indicator works on a new and very interesting principle. Imagine a piston to one side of which is applied a steadily increasing air-pressure, whilst the other side is subject to the varying pressure in the engine cylinder. It is obvious that at the instant when the two pressures are equal the piston will be in equilibrium, and that the slightest increase of the engine pressure will cause it to move. If the piston is caused to break an electrical contact, then a record may be obtained of the very instant at which equilibrium was passed. A second record will also be obtained when the engine pressure is falling; for, in that event a moment will be reached when the air pressure will overcome the cylinder pressure and drive the piston back again. That is the principle of the R.A.E. indicator. By the provision of suitable means, the records are made by an electric spark on a revolving paper drum. This indicator has the very great advantage that there are no reciprocating parts, and, consequently, no inertia effects, but it has the drawback that a considerable number of cycles—as many as 125—are required to produce a single card. The reduction of the autographic records to the familiar form occupies a good deal of time. Nevertheless, for special purposes, as, for example, the indication of aeronautical engines in flight, it is a most promising invention.

All indicators designed for the highest speeds differ in one important respect from the familiar mechanical indicators. Their portability is far less; they are, without exception, rather the instruments of the laboratory than of the engine-house or its equivalent. There remains therefore still plenty of scope for the invention of an instrument which could be carried about as readily as a Tabor or a Crosby, which could be used on board a motor ship, a motor lorry or an aeroplane, and which would enable us to indicate such engines with as much precision as moderate-speed steam engines and internal-combustion engines. The miniature diagram indicator produced by the Cambridge & Paul Instrument Co., approaches, at the moment, most closely to the requirements.

The Drum and Its Mechanism.—Attention must now be directed for a few moments to the drum and its mechanism, and to the equivalent devices in indicators of special form. Simple as it may appear to be to copy precisely, on a reduced scale, the movement of a piston, it is in fact,



Crosby "New" Indicator *Crosby Valve and Engineering Co. Ltd.*

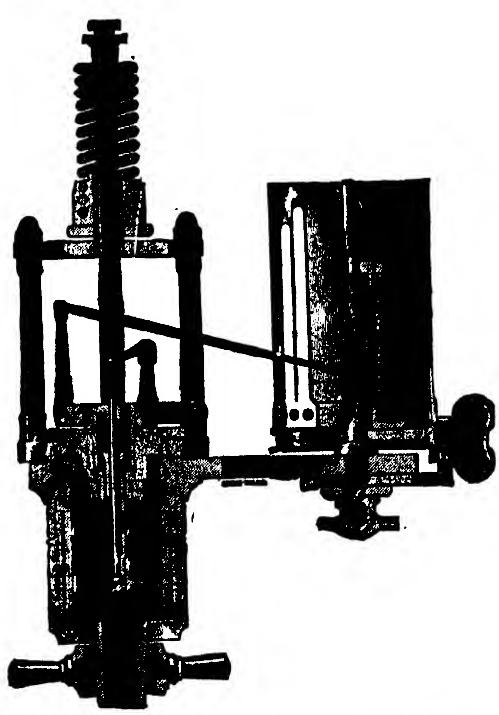


Showing External Flat Spring

a problem of some difficulty at anything above speeds not exceeding, say, 300 or so r.p.m. The problem may be divided into three parts: (1) disturbances caused by the reducing-gear itself; (2) disturbances caused by the cord, and (3) disturbances in the drum. Under the first heading we have to deal with the ever-present obstacle of inertia and with defective joints, in the second with elasticity, and in the third with inertia once more, and—in mechanical indicators—with the drum spring, which should, by preference, maintain a perfectly constant load on the cord. It cannot be said that any devices in common use have solved these problems, and a certain small percentage of error is always due to them and gets larger and larger as the speed increases. It is probable that the best way to overcome them is to give up the attempt to do so and to move the paper, as in continuous indicators and in the Mathot indicator, by clockwork, but when it is remembered that a complete cycle is effected in one-thirtieth of a second in an engine running at 1,800 r.p.m., it will be seen that to obtain separate cards about 3 in. long the paper would have to have a speed of well over 90 inches per second, and the nature of the difficulty will be understood.

It is impossible in the time at our disposal to deal with all the problems connected with the reducing mechanism and the influence of the cord. It must suffice to say that for speeds above 500 r.p.m. no reliable reciprocating gear has been yet invented, and to refer those who desire to study the subject to the literature of the subject. Neither is it possible to devote time to the question of the effect of temperature upon helical springs. It is known to be important, and as a consequence the use of indicators with external springs has greatly increased. Unfortunately in some designs it is found necessary to use an extended piston-rod which causes an increase of weight and inertia.

Springs and Pistons.—The influence of piston friction was not fully appreciated until attempts were made to use indicators at high speeds. As soon as it was recognised, the causes were examined and the distortion of the spring under load was immediately noted. It is well-nigh impossible to make a helical spring so accurately that whilst being compressed it will



Crosby "New" Indicator in Section

Crosby Valve and Engineering Co. Ltd.

not lose its truly cylindrical shape. To reduce or obviate this difficulty the double helical spring was introduced by Crosby, and the piston was given freedom of motion by the adoption of a ball-joint. The necessity for accuracy in this ball-joint was pointed out in the discussion on the paper contributed to the Proceedings by J. G. Stewart in 1913. Whilst it is desirable to leave the piston as free as possible, it should be pointed out that the ball-joint will not prevent the piston from being pressed against one wall or other of the cylinder. The spring is held rigidly at one end, and distortion of it will tend to move the other end laterally. The ball-joint cannot overcome this effect. It could only be removed by having a ball at each end of the spring, a plan which, as far as the author is aware, has not been tried, though, as shown later, a good arrangement is used in one well-known indicator.

(To be continued.)

Wood Refuse Gas Producer Plants

An interesting plant manufactured by The Dowson & Mason Gas Plant Co. Ltd., Manchester, for the gasification of waste wood.

THE type of gas producer plant which is most generally used in England for comparatively small powers is that in which anthracite or coke is used as fuel. The suction or suction pressure plant is universally known, and there is now no question as to reliability or the cost at which the gas can be generated. This cost may be taken as round about 4½d. per 1,000 cu. ft. with anthracite at 55/- per ton. Numerous attempts have been made to evolve a cheap and reliable plant capable of using bituminous coal, and it is now possible to purchase such a plant at very little more than the cost of one designed to use anthracite.

Considerable attention has, however, of late been given to gas producer plants in which wood refuse or vegetable matter can be used. Many such installations are now in successful operation, and as the fuel cost is exceedingly low, and in some cases nil, it will readily be understood that where such fuel is available, gas suitable for use either in gas engines or furnaces can be produced at a lower cost than with any other medium. It is therefore of great importance to manufacturers who have waste wood or vegetable matter, such as paddy husks, cotton seeds, olive refuse, etc., available, or who are situated in districts where this fuel can be readily obtained, to take note of the plants which are available for dealing with it, and the cost at which the gas can be produced. We illustrate in Fig. 1 a plant manufactured by The Dowson & Mason Gas Plant Co. Ltd., Levenshulme, Manchester, for the gasification of waste wood, etc.

Naming the parts, A is the generator, B the cascade washer, C the tar extractor, and D the sawdust or wood wool scrubber. The physical qualities of wood and similar refuse are very different from those of coal or coke, and the calorific value is much lower. It is essential, therefore, that the plant be designed on more generous lines, and provision made for the physical variations.

In the first place, it will be noticed that there is no vaporiser provided with a plant of this description, as it is very seldom that steam is required for the proper gasification of the fuel. The wood refuse in most cases contains a lot of moisture, sometimes up to 50 per cent., which is largely driven off in the generator during gasification. It is a lighter and quicker burning fuel than coal, and much more is consumed per b.h.p., therefore a correspondingly greater area must be allowed in the generator for gasification. Seven square inches per b.h.p. inside the generator lining is an average figure for anthracite coal, but up to 20 square inches is often allowed in a wood refuse generator.

The bottom of the generator also differs from that of a standard open hearth plant in that it is encased and the grate closed in, doors being provided for the removal of the ash whilst the plant is running. These doors are partly open all the time, to admit air for combustion, the amount of the opening, which depends on the fuel, being easily regulated by means of a quadrant secured to the doors.

Enclosing the bottom of the generator obviates any difficulty which might arise from too much draught, and also prevents the ash, which is light, from being wafted about.

Looking at the top part of the generator, it will be seen that a large fuel container is provided; this is, as a rule, filled up to the top with fuel when the plant is working. This container holds the fuel ready for gasification, which automatically descends into the generator proper, thus forming a gradual and constant feed. With this means of supply the generator can be left without charging for longer periods, and the ingoing fuel is partly dried before actual contact with the fire; and, further, it tends to minimise

any air leaks from the top into the generator.

Another feature of wood and similar refuse plants is that owing to the excess of volatile matter in the gas, the pipe connections tend to block up, and means are provided to remove any obstruction occurring during working. Scrapers are fixed permanently into the most vulnerable pipes, being drawn back to the ends of the pipes when not in use. Removable handles are provided, which are attached to the scrapers from without, and with these the scrapers can be moved to and fro, and any dirt, etc., removed.

Large areas and clear passages should be provided wherever possible, and free use made of water for scrubbing and cleaning purposes. An efficient cleaning plant is vital, particularly where some types of vertical engines are used in conjunction with the plant. Where a coke scrubber is employed for coal or coke, a scrubber, without filtering material but arranged to bring the gas into intimate touch with the water supply, is usually provided for wood refuse. In the cascade washer shown in the illustration, the tar is swilled down from one plate to another, finally being deposited in the sump in which the washer stands.

The tar extractor must be capable of beating out the remaining tar and removing the tar fog in the gas ; it is practically always of the centrifugal type, running about 2,000 r.p.m. A large settling tank, of concrete, built in the ground, is provided to receive the discharge from the tar extractor. Weir boards are fitted in the tank to give the water a definite flow and enable it to deposit the tar and so leave the tank fairly free from dirt.

This type of plant is usually opened up for inspection every two weeks, and the filtering material in the sawdust scrubber changed every month.

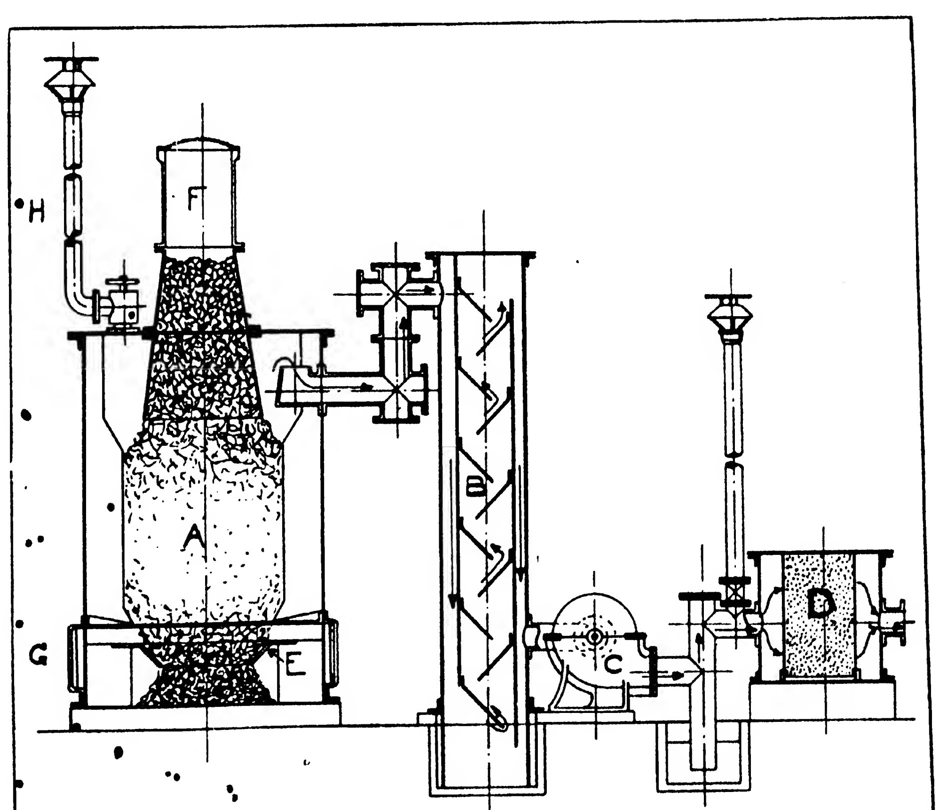
The sizes of plant manufactured by the Dawson & Mason Gas Plant Co. Ltd. range from 30 to 300 b.h.p. in one unit ; for higher powers these units can be conveniently arranged side by side and coupled by a common main.

An installation such as we illustrate undoubtedly offers an attractive investment to any manufacturer who has a supply of refuse to dispose of.

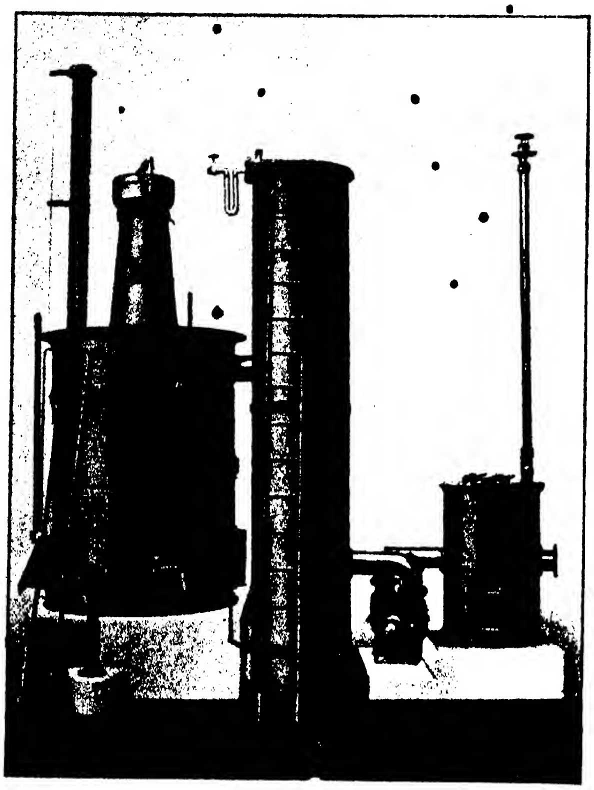
An adaptation of the wood refuse plant which is used for the gasification of peat and lignite is shown in Fig. 2.

This particular plant is of 110 b.h.p., and is at present running on peat containing 45 per cent. moisture. The consumption of dry peat over a week's run averages 2.84 lb. per b.h.p. hour.

In England the average cost of producing gas from anthracite is as follows :-



Section through Producer and Cleaning Plant



General View of Plant

Working Costs for Anthracite Suction Gas Plant when Running on Anthracite, costing 55/- per ton.

Based on Gas Plant of 250 b.h.p. capacity.

Assume continuous running, *i.e.*, 144 hours week.

Coal consumption, .9 lb. per b.h.p.

Anthracite used in gasification per week (144 × .9 × 250) ...	32,400 lb.
Anthracite used in stand-by (24 × 2)	48 ,,
	32,448 lb.

= say 290 cwt. = 14½ tons.

	£	s.	d.
Cost of anthracite (14.5 tons at 55/- per ton)	39	17	6
Cost of attendance	5	0	0
Water, 54,000 galls. at 1/- per 1,000	2	14	0
Interest 6%	0	10	0
Depreciation 5%	0	8	0
Repairs, etc., 5%	0	8	0
	£48	17	6

= 11,730 pence.

Cubic feet producer gas made per week, 250 × 70 × 144 = 2,520,000.

∴ Cost per 1,000 cubic feet,

$$\frac{11,730}{2,520} = 4.6d.$$

If the cost of the waste wood in any particular locality is substituted for the cost of anthracite, and the consumption per b.h.p. altered to 3 lb., leaving all the other costs as they are, the cost of the production of the gas from any of the fuels named in this article will be obtained.

The gas produced by these plants can be used for all kinds of industrial heating operations, as well as for driving gas engines.

BETWEEN OURSELVES (*Continued from page 580*)

stinting themselves in other directions. "Economy" undoubtedly gives chapter and verse to prove his contention that the third class passenger on the Indian railways is hopelessly and inadequately catered for. It would almost seem from his figures that as the third class passenger increases, the supply of third class coaches is cut down in direct ratio. And yet in a statement he gives showing the results of the 10¼ years ended the 31st March, 1920, on the Great Indian Peninsula Railway, while a profit of no less than 1050.55 lakhs was wrung out of the third class passenger, the first class passenger traffic not only did not give a single pie as profit, but involved a loss of as much as Rs. 84.55 lakhs. Surely somebody should sit up and take notice.

THE Dowson & Mason Gas Plant Co. Ltd. ask us to state that their Agents in Eastern India are Associated British Engineers Ltd., Calcutta.

* * *

IN our next issue we hope to publish a fully illustrated article on the manufacture of tea. This we are doing at the request of a number of correspondents who have asked for detailed information upon this important subject. We may state that we shall continue to deal with various industries in turn, and that we shall be pleased to advise our readers on their choice of plant and equipment without charge or obligation of any kind.

ORGANISATION

Conducted by HARTLAND SEYMOUR

THIS SECTION DEALS WITH WORKS MANAGEMENT AND ORGANISATION, THE TRAINING AND WELFARE OF THE WORKERS, AND WITH THE ADVERTISING, SELLING AND MARKETING OF GOODS

The Principles of Organisation and Management*

"The old order changes" and the man who is prepared can meet the New

THE value of organisation was made conspicuous by the war, which was probably but a purging of the old order of things. Probably some years will be required to complete the work of reconstruction, but it is certain that we are commencing a new cycle which will be one of development.

The power which will enable us to carry on during this period is organisation, without which it would be impossible to do more than a fraction of what is necessary.

Everything that we do or say, everything that is made or used, is the product of the brain, and in the final analysis human thought and energy is the power behind everything. The success of an enterprise depends entirely upon the men who are charged with the care and handling of its material resources. Consequently, as the personnel is developed the organisation is strengthened, and conversely as the organisation is strengthened human effort is made more effective.

Organisation, therefore, is the proper adjustment of the relationships between human beings in an effort to accomplish certain definite ends. The degree to which this adjustment is correct, logical, and on sound lines determines the resultant success of the organisation.

Originally the author regarded organisation as a cold-blooded adjustment of departments, but he now prefers to substitute the word "organism" for the more usual term. It is animate rather than inanimate, and a business is (or should be) a living, pulsating organism, which should function methodically without confusion, delay, or misinterpretation, yet with a flexibility which allows for the initiative of the individual.

Good organisation implies clearly defined plans and ideals, and efficient co-ordination and co-operation of capital, labour, and management in carrying them out. Efficient management will then look to the development and direction of the great sources of power in the personnel of the business, so that each member contributes his quota to some constructive plan. The resultant should be the exact control of the business, so that there shall be the maximum of efficiency.

Thus the ideal of an efficient organisation should be that of developing the individual. This in itself is a high aim, but in order to make the ideal practical of attainment it must find expression through a type or organisation which will recognise and apply correct principles, laws, and rules.

It may be taken as axiomatic that the success of an enterprise depends very largely upon the way in which its resources in time, effort, material, and money are organised and managed. In the past a good organiser and manager was looked upon as a man who possessed his skill by some intuitive faculty. It was regarded as a sort of gift, and not as something which could be acquired.

This idea gained currency mainly for two reasons:

(1) Business enterprise during the last fifty years has passed through a state of flux. It has evolved rapidly from the one-man business to that of huge enterprises and company formations, in which the ramifications become so complex that it may truly be said that business to-day entails the merging of half a dozen professions into one.

An enterprise no longer takes three generations to come to fruition. Resources in the matter of capital, machinery, publicity, modern methods of salesmanship, costs, and accounting have carried the activities of even a business of moderate size beyond the point where a single man can carry the whole load of responsibility. A business undertaking is really a community of interests. Shareholders must be considered, whilst consumers' demands must be met by greater production. This necessitates the employment of a large number of workers for the factory, the office, the shop, and the sales department. With all these factors at work there is an urgent call for men who can so organise the various activities that the task of management becomes one of obtaining co-operative effort towards a common objective, namely, that there shall be economic production and distribution combined with equitable remuneration to shareholders, management, and workers, with the lowest possible price to the consumer.

With this rapid growth of business enterprise there has been little or no time to formulate definite principles from the accumulated experience of those who have built up these organisations. The executive must rely largely upon his own judgment, based upon his experience and natural ability. He has had to learn by trial and error, which is a costly and lengthy process, but the only one possible under the circumstances. In any case, he has not, in the majority of cases, made known the methods he employed, possibly because he had wrought them in the hard school of experience through arduous and steady effort, and was not inclined

*Being a Paper presented to the Institution of Production Engineers by Mr. Wallace Attwood, Member of Council, M.I.P.E., of the Wallace Attwood Efficiency Service.

to give away that which had taken him years to acquire.

(2) Much has been written in various business journals and elsewhere on the way in which certain enterprises carried out their work. In the main, however, such descriptions have dealt with the effects produced, giving many practical details which, in themselves, were valuable. They have, however, given little or no consideration to the formulation of definite principles, so that these could be appreciated and applied by the man who wished to become a capable organiser and manager.

It frequently happens that the man who is carrying out successfully his executive duties is not given to generalising, since he is compelled to concentrate his energies in building up his department or enterprise from the personnel and material available and the problems which confront him from day to day. He deals with the realities of the daily situation and adjusts his organisation to meet them. Gradually he evolves his own methods without many opportunities of weighing them against the methods adopted by other executives. His mind is too busily engaged upon bringing his own organisation up to a state of efficiency. Accordingly it is not surprising that this problem of organisation and management has scarcely been dealt with upon a recognised plan, to formulate definite principles and to indicate their application in a logical sequence.

The Main Elements in Organisation and Management

In order that at the outset the line of demarcation between organisation on the one hand and management on the other may be made clear, and to indicate that the author has evolved what he believes to be a logical plan, it is desirable to consider the following analysis, together with a brief descriptive explanation :

I. *Organisation.*—This may be considered under a number of stages, thus :

- Analysis.
- Synthesis and arrangement.
- Functionalisation.
- Routine.
- Determination of personnel.

II. *Management.*—This also may be treated under the following headings :

- Direction.
- Training.
- Appointing or deputing.
- Control.
- Supervision.

I. *Organisation* consists in determining the relationships between, and in terms of, money, time, effort, and material for accomplishing a given task. It is concerned with laying down proper plans which shall form the basis of some constructive work, and can be dealt with independently of the actual task which it is the object of the organisation to carry out. Much in the same way an architect can draw up a plan in his own office for constructing a building once he has obtained the necessary data regarding the structure in question.

It is quite possible to possess organising ability without managerial ability. In fact, in large businesses it is common to find a highly skilled executive who does the organising. He may not be much in the public eye, since he leaves the carrying out of his plans to other executives who have greater managerial ability.

The four steps which make up organisation may now be briefly discussed.

Analysis

Obviously the first stage consists in analysing the problem. Exactly what it is required to accomplish must be determined. Thus it may be the organisation of a particular department, or the problem may consist in adapting the existing organisation to undertake certain new work. Again, it may be desired to deal with some department or section which is unsatisfactory and to convert it into an efficient working unit. Clearly there must be some objective, otherwise there is nothing to accomplish. Whatever the object, then, the first thing will be to diagnose the present position and to collect all data, experience, and so on, which can help in the elucidation of the problem. In other words, an investigation is made as to what the problem really is, how much has been done so far to carry it out, what still remains to be done, and what available data there are to assist in its solution.

Synthesis and Arrangement

With the objective in view, plans are drawn up with the aid of the available data and experience, so that the inter-relationships of the various units in the plan obey certain definite principles.

To refer once more to the architect in arranging (or organising) such units as a fireplace, doorway, and the windows of a room, he will bear in mind the principle that the doorway must be wide enough to admit the furniture that will be required for a room such as he is designing. He will be careful to remember that if the doorway faces the door of the entrance hall, then the fireplace must not be placed in line with a possible draught. Again, the space left for the windows must have some relationship to the size of the room.

When the elementary principles upon which to organise have been agreed upon, it will be found just as simple to apply them as it is for the architect to arrange the above details in his plans. Further, the plan can be tested against the principles before it is put into execution, thus rendering it reasonably certain that the plan will work and enable the objective to be achieved.

Functionalisation

Having arranged the scheme of organisation it will be necessary to take its component parts and determine the particular functions or duties which each section should carry out. In doing this, care must be exercised to ensure that there is no duplication of work, and that there are no essential functions which cannot be achieved by the plan, in which case the plan would need to be remodelled.

The architect submits his plan to some such scrutiny, and in so doing he will determine the functions of each room and each feature of the structure. He may find that he has planned two rooms for identical purposes, which entails waste of space and money. On the other hand, he may not have provided sufficient bath rooms for the type of house that he is constructing. In any case he must satisfy himself that his plan contains nothing superfluous, but at the same time embodies all the requirements of those who wish to live in the house.

Routine

At this stage it is necessary to lay down the exact procedure by which each unit, section or department will be able to carry out the functions allotted to it. In business this is often called the system that the business adopts for carrying out its work. Arranging the routine of a business always occupies a considerable portion of the time of an executive.

Returning to the analogy with the work of the architect, he would be able at this point to submit his plans to the man for whom he is building, and point out the routine which would be necessary when occupying a house built to those plans. He would show

how the front entrance is approached from the road, and how from the hall there led off the cloakroom, the reception room, dining room, etc.; also that there was easy access from the kitchen to the dining room, whilst at the same time the kitchen remained in the background with reference to other rooms. Anyone can easily picture further details for himself.

The half-way house has now been reached. The organiser has done his work, having formulated his plans and laid down the lines on which they will be carried out. At this point the human element comes into play. Capital, plant, equipment, material, organisation, plans, routine, are of no avail until they are translated into productive elements by the personnel. Consequently, the pivot between organisation and management is the mobilisation of those people who are to carry out the routine which executes the plan and accomplishes the task.

This step, therefore, is concerned with the allocation of the individual to that section of the routine which it is predetermined he should carry out.

Management

It is one thing to formulate plans; it is quite another to carry them out. Management is concerned with the last-named function, and it is quite possible for an executive to make a scheme work, although he may not be capable of originating it.

Strictly speaking, the word management is derived from the Latin *manus*, which means "the hand." The dictionary gives the meaning thus:—

"To guide by the use of the hand; to have under command or control: to bring round to one's plans: to conduct with great carefulness: to wield: to handle: to contrive: to train by exercise: to conduct affairs."

From this it will be gathered that management is responsible for translating into action that which has been organised, and the manager of to-day has to concentrate upon handling men, money, materials and processes with his mind rather than with his hands. But, in the final analysis, the art of good management will resolve itself largely into the art of handling men.

The five divisions under management may now be briefly considered.

Direction

The successful manager must be able to direct the efforts of others. His knowledge of human nature, and the special aptitudes of those whom he engages to help him, as well as a clear insight into the plans and routine of the organisation, will enable him to assign the right tasks to the most suitable men. This is the first step in management.

Training

Having allotted the duties he must see to it that each individual has every opportunity of perfecting himself on the work with which he is concerned. He must, therefore, plan to train the men in their jobs, and it will be found that in the majority of businesses the management is seriously at fault in this work of training. The individual is left to fend for himself, which means that he very soon falls into a rut, and remains there.

Appointment and Deputing

At first the manager carries a heavy share of the load, but as he directs and trains the personnel he should experience relief in many directions. His staff should grow, and with growth they will be able to assume more and more responsibility. The manager, therefore, seizes every opportunity of deputing his work to his lieutenants; the lieutenants assign duties to the warrant officers, and so on down the line, until even the rank and file are given opportunities of carrying a little extra load.

Control

As the manager is relieved of more and more of his routine work he is left with greater time in which to control the staff, and the work that has been deputed to them. The nearer the manager can approach to the point where he controls, directs, and trains, instead of becoming involved in details, the nearer will he get to the ideal manager.

Since the manager must ultimately take sole responsibility for the execution of the plans which he has drawn up, or which have been prepared for him, he must keep effective control, otherwise the management passes from his hands, wholly or in part, to others.

Supervision

There must be a constant overhauling of the work carried out by the personnel. It is only human for errors to creep in, and duties are apt to be performed in a slip-shod manner. Certain workers may also introduce modifications of the routine, which, whilst good in themselves, may have serious consequences when considered in relation to other duties. Further, as time goes on, defects in the original plan may become apparent, rendering adjustments necessary.

For these and other reasons the manager must maintain or arrange for effective supervision from day to day over all the activities of the staff.

The above brief explanation should give a clear conception of the work that lies before one who desires to become an efficient organiser and manager.

(*To be continued.*)

A FACTORY DRIVING ENGINE

In starting a new industry overseas, one of the first problems is to find a convenient source of power. Transport difficulties often stand in the way of obtaining a heavy steam or oil engine, generally adopted for power purposes. To meet this difficulty, a British firm has developed a self-contained factory engine of 28 h.p. running at a speed of about 900 r.p.m. This equipment is specially arranged for convenient transport to places remote from the sea, river, or railway. The engine is designed to run on ordinary paraffin, and its parts are made completely interchangeable, so that repairs and replacements can be very readily carried out. The whole machine is mounted on a solid steel frame which forms a bed-plate, reducing vibration to the absolute minimum. This engine can be run at full load for long periods without requiring any make-up water.

HUGE STEAM SHOVELS

The machinery recently sent out by a British firm for use on a big harbour construction job in Africa includes three of the largest steam shovels ever built in Great Britain. Each machine takes out 3½ cubic yards of material in every movement, yet it is so constructed that it remains perfectly firm on a 3 ft. 6 in. gauge railway. Each shovel is provided with three operating engines and main hoisting engine (which is also used for travelling), a swinging cradle, and thrust engine. A steam-driven air compressor is also fitted to the shovel for driving drills which bore into the rock for blasting purposes. There is also an ample lighting equipment which enables the machine to be worked after dark.

The Efficiency Engineer and the Industrial Psychologist*

By CHARLES S. MYERS

Half the troubles in the industrial world to-day are due to misunderstandings. This article shows how the pioneers of a new movement spoil their efforts by a false point of view.

TO-DAY I propose to address the efficiency engineer from the standpoint of the industrial psychologist, pointing out the limitations of his work unless it be carried out with continual and due regard for its psychological complications. Of course the psychology of the worker under different social conditions and in different countries differs widely, and my apprehensions as to the consequences of the attitude assumed by certain efficiency engineers will not necessarily apply to countries other than that from which my experience of the worker's psychology is derived. Still, in no circumstances whatever, would it appear justifiable to tell a workman to-day what Taylor, admittedly in "rather rough talk," said to the "little Pennsylvania Dutchman" Schmidt, whom he was instructing in the best methods of handling pig-iron,—"You know just as well as I do that a high-priced man has to do exactly as he's told from morning till night." (*a*) That is, of course, precisely what the worker fears will result from the application of motion study. If experts, appointed solely by the employers, are to go round the factory, observing, codifying and standardising the most efficient methods of carrying out different operations, the worker will be robbed, so he suspects, of his craft skill and will come to be treated, so he imagines, as a piece of machinery which without option has to carry out prescribed operations at a prescribed speed by prescribed movements.

Throughout a paper presented by Dr. and Mrs. Gilbreth to the Barcelona meeting of the International Conference on Vocational Guidance, their guiding principle is the "determination of the One Best Way to Do Work." It is necessary, they insist, "for the Psychologist to understand that the Quest of the One Best Way is the crux of the present industrial problem. . . ." To this the adequately trained psychologist retorts—"there is no 'One Best Way.'" The psychological and physiological differences between individual workers are such that it is useless to train and to expect all to perform the same operations in precisely the same way. Such an aim is harmful in practice, because it discourages all initiative; and it is impossible to achieve, because no two individuals can be trained to precisely the same features of rhythm and movement. Each brings with him a certain style best suited to his mental and physical constitution. No two champion golfers would provide Gilbreth with identical "chronocyclegraphs"; what Taylor calls "rigid rules for each motion of every man" (*b*) do not exist. To force all into a common mould is not only to act contrary to the dictates of Psychology and Physiology, but also to encourage the worker's only too natural belief that the management seeks for its own benefit to deprive him of the craft knowledge, that sole possession which he and his forebears have acquired for general tions past. Thus the industrial psychologist is diametrically opposed to Taylor's ideal of Scientific Management that under present usual conditions "the managers assume . . . the burden of gathering together all the traditional knowledge which in the past has been possessed by the workmen." (*c*) Whatever information of this kind is obtainable can only be satisfactorily collected with the full understanding, consent and co-operation of the workers; in this connection Taylor's statement that "there are many cases" where secret timing is unavoidable ("Shop Management," page 1426, footnote) is in flagrant violation of the principles of industrial psychology.

The experience of the National Institute of Industrial Psychology has been that the workers' confidence and collaboration *can* be obtained. In its investigations on breakages it has been able to obtain reports from the workers as to how each breakage occurred; in those in a coal mine it has been able to train miners to swing the pick according to the beat of a metronome. Such procedures would be impossible in an atmosphere of suspicion and unfriendliness.

The efficiency engineer commonly proceeds by analysing a given operation into a number of different parts, observing and tabulating the movements of that operative who performs one of those parts in the quickest time, the movement of another operative who performs another part in the quickest time, and so on; finally collecting into one series the quickest and best movements, (*d*) which is then stereotyped and forced on every worker as "the One Best Way." Psychology and physiology, however, teach that an organism is more than a sum of parts thrown together haphazard. The individual has characteristics which are not to be found in his isolated parts, and his best mode of movement is not necessarily to be derived from a combination of more elementary movements selected from different operatives on a basis of speed. Nor, indeed, without adequate evidence is it justifiable to conclude that the speediest or the shortest movement is necessarily the least fatiguing. Farmer's investigations in this country have afforded some conclusive illustrations of an opposite relation: a longer continuous sweeping movement may prove far less tiring than a series of shorter angular ones, and a slower rhythmical rate may of course be more effective in the end than a faster one.

It should be one of the functions of the Trade Unions to inquire into good and bad methods of work and of training and into the wide individual mental differences which demand different methods of work and of training, and to insist that their members obtain adequate and suitable training in their occupation. "No worse mistake," said Taylor, the acknowledged father of modern

*Abstract of a paper read before Section J (Psychology) at the Hull Meeting of the British Association, September, 1922.

efficiency engineering, "can be made than that of allowing an establishment to be looked upon as a training school, to be used mainly for the education of many of its employees."(e) The industrial psychologist insists that an establishment depends for its very life and efficiency on the extent to which it is utilised as a training school and as a means of properly educating those who work there. Can anyone suppose that the best mode of getting the best work out of an employee is by bidding him, in Taylor's words, "bear in mind that each shop exists, first, last and all time, for the purpose of paying dividends to its owners"? (f)

By nature and through his training the efficiency engineer is prone to regard human workers as machines. Rather than understand them, he would mould them to a common type. Instead of trying to appreciate the various emotional influences and incentives which affect the worker's efficiency, the efficiency engineer is led by his mechanistic interests rather to determine and to set the tasks which may be expected of an efficient worker, and to devise some elaborate scheme of payment which, in his fond imagination that prescribed tasks and bonuses are the main incentives to production, will induce the worker to give his best. (g)

From the same standpoint, the Engineering Correspondent of the *Trade and Engineering Supplement of the Times* (August, 1920) insists that the sole function of the industrial psychologist is to give a "plain and uncoloured statement of the facts they are asked to measure" and not to concern themselves "with either the ethical or the economic aspects of the operations on which they are asked to advise." This seems to imply that the psychologist is debarred from inquiry into the existence and origin of factory worries and discontent, and that he can always satisfactorily "measure the facts" without investigating other often widely remote but complicating conditions of a psychological character. In actual practice, the industrial psychologist may find it essential to extend the initial scope of his inquiry in this way. And provided that he has the confidence of the employer and of the employed, he should be at liberty to do so.

From his mechanistic standpoint the efficiency engineer expects man to behave like a machine, turning out (ideally) a constant hourly output throughout the working day. The industrial psychologist recognises and investigates the various factors that inevitably enter into, and influence the form of the work curve, and the different play of these various factors, at different times of the day, with different kinds of work, and with different types of worker. Life-long workers cannot be compared with the crew of a racing eight, or with a regiment on parade, trained to relatively brief periods of identical or uniform rhythm of action. Nor are the laboratory investigations which have been carried out by the "pure" experimenter with ergographic and mental tests in which the maximum of effort is throughout induced, directly applicable to the conditions of work-a-day life. (h) The worker is neither a machine working on purely mechanical principles, nor an organism stimulated to produce its very utmost. The industrial psychologist, especially through the observations of Vernon and others in this country and Lee and his colleagues in the United States, has ample evidence now of the way in which the worker unwittingly adapts his hourly output to the total length and severity of his day's work, his work curve depending for its form and height on the length of each work period and on the nature of the work in which he is engaged.

Let us turn now to the attitude of the efficiency engineer to tests for vocational selection. The psychologist, the Gilbreths believe, "must not only make the tests for himself, but must also see that such tests can be used by managers who are not psychologists." I am not sure what reliance the engineer would place on the results of a test, say, of brake horse power, applied to an engine by one untrained in engineering; but I am confident that the use of any kind of mental (or bodily) test by one untrained in psychology (or physiology) has an extremely limited value. A test of mental (or bodily) aptitude is not an instrument comparable, say, to a voltmeter, which only needs to be mechanically brought into contact with a metallic substance to provide an accurate measurement of electromotive force. The numerical data afforded by vocational tests can only assist, they can never solely or mechanically determine our appreciation of an individual's special aptitudes. One must be ready to take into consideration not only what a person does at a test under given conditions, but also how he carries out that test, and not only the extent and manner of his performance in that particular test, but also his entire personality. Vocational tests are to be regarded as the servant, not as the master, of the industrial psychologist. They promise to be of the greatest value to him, but they always require interpretation in the light both of observation of the individual tested and of the industrial, psychological and physiological knowledge and experience of the observer.

(a) "The Principles of Scientific Management." New York and London: Harper & Bros. 1916. Page 45.

(b) *Ibid*, Page 85.

(c) *Op. cit.*, Page 36.

(d) *Ibid*, Pages 118, 119.

(e) "Shop Management." London: Hill Publishing Co. 1911. Page 1419.

(f) *Ibid*, Page 1419.

(g) "Each man," says Taylor, "should daily have a clearly defined task laid out before him. This task . . . should not be easy to accomplish. . . . When he fails he should be sure that sooner or later he will be the loser by it. . . . It is useless to assign a task unless at the same time adequate measures are taken to enforce its accomplishment." *Ibid*, pp. 1368 and 1372. Let every reader reflect on the mental effects of such a principle on himself.

(h) I am in full agreement with the Gilbreths that laboratory research work is inadequate, especially when carried out by those ignorant of factory conditions, and that it requires supplementing with investigations carried out under industrial conditions.

AUTOMATIC BRUSH MAKING

The original forms of brushes were of course made entirely by hand, and until recently all brushes had to be produced by a combination of machine and manual labour. A British firm of engineers, however, has developed a most ingenious machine which is wholly automatic in its action. This machine drills blind holes in the back of the brush, selects tufts of bristles from a bundle, doubles each tuft and fastens it with wire clips at the bend, and then inserts each tuft in a hole. The wire clip is so designed that when the tuft is inserted, the clip opens out, and its two ends penetrate into the wood and thus prevent the bristles from being withdrawn. This remarkable machine is made in three sizes for dealing with brushes of different dimensions.

Factory Management Wastes

By J. F. WHITEFORD, M.A.S.M.E.

Lecture before the Birmingham Branch of the Institute of Industrial Administration.

THE curse of the civilised world to-day is not Bolshevism, nor Capitalism: it is not labour unions, and it is not employers' federations. The curse of mankind to-day is waste—preventable waste.

Industrial wastes exist to-day because individuals refuse to accept the responsibilities attending their individual acts. If the waste in industry is eliminated, the world, the community and the individual will benefit. So in discussing the question we have first to allocate the responsibility.

Now in speaking of waste I do not mean waste of material, because that form of waste is visible. You can see it. You have only to go to the scrap heap and see that material has been wasted. When I speak of waste, I refer to misapplied and misdirected energy. That is something which you cannot see, and that is the reason why there is so much of it. Wasted material requires no imagination to appreciate, but it is entirely different with misdirected energy.

Classes of Industrial Waste

Industrial wastes existing to-day can be divided into four classes: "Faulty Management," "Intentional Restriction of Output," the waste resulting from "Disabilities," and the waste which comes from "Idleness."

Of the total waste in industry to-day there is fully 65 per cent. for which the management is entirely responsible. Labour is probably responsible for 25 per cent., and the remaining 10 per cent. you can attribute to the wasteful methods of the community at large.

It is a serious matter when the management of industry is responsible for 65 per cent. of the preventable waste, which can be eliminated without reference to the labour factor.

These wastes, in the order of their importance, are:—

(1) Imperfect design.
(2) Inadequate production control.
(3) Ineffective co-ordination of the sales and production sections.
(4) Inaccurate costs and statistics.
(5) Improper working conditions; and
(6) Incompetent personnel.

Imperfect Design of Product

Now to sketch briefly these six classes beginning with the question of design. The designers of a product concern themselves largely, if not entirely, with the operation of that product. They do not concern themselves with the production of that product. The net result is that the producing side of the business has to make up for all the shortcomings of the designer.

Take, for example, a machine which has not been properly designed and has too many parts. Only recently I heard of a machine where 500 working parts had been eliminated. The machinery, the organisation, the equipment, and everything connected with the production of those 500 parts were unnecessary. Every unnecessary part only serves to increase the volume of waste.

Probably the best known example is in the motor industry. Some years ago I discussed this question with a leading motor car manufacturer. He was producing 26 different designs of cars, and I suggested that the number was too many. He said: "I must serve my customers. They want different types of cars, and I must meet their wishes or go out of business." I said: "I do not agree with you, although at present you make a car largely to the specifications of your customers. But do they know the correct length of wheel base, the correct diameter of the cylinders and the length of stroke which suit the best type of car, and are they in a better position to specify the various details of a car than a motor car manufacturer? As the result of your experience, are you not in a better position to tell them what they want?"

He did not agree with me, but in the meantime a genius developed in the motor car industry who forced the issue. This man had the tenacity and the common sense to stick to a few fundamental principles in the manufacture of motor cars. The net result is that he is manufacturing 65 per cent. of all the motor cars that are made in the world.

This man was not prepared to make as many types of cars as there were customers who wanted some modification. He adjusted the design to suit methods of manufacture, and to-day he is practically dominating the motor car industry of the world. And there is no good reason why the Ford plant could not have been in Birmingham instead of Detroit.

Now to take an illustration apart from motor cars. I know of one factory which manufactured containers for its products. There was a great waste of material. Seeing the material waste the management could realise there was waste to be eliminated, but they did not realise that they were making in all 1,400 different sizes of containers when 300 were sufficient.

When this form of waste was realised and eliminated they increased the capacity of the factory about 50 per cent. Being machine production they could get very much longer runs, fewer machine changes, and the net gain, of course, was tremendous. In those cases we can attribute all of the waste to design.

Inadequate Production Control

Next the question of production control. When I remarked to a managing director that he did not have his factory under control, he said: "Everybody does what I tell them to do. I can get anything done I want to in the factory; I know what is going on. What do you mean by telling me my factory is not under control?" I asked: "How long

does it take ? What is the minimum of time from the raw material coming into the factory to when it comes out as the finished product, and what is the actual time ? " He did not know, but within a few months he had increased the output by planning ahead, by arranging the work of the different departments so that all the work was co-related. He had increased the output by 65 or 70 per cent.

The product of the factory concerns all departments, and it is necessary to keep the work in balance. How do you suppose the railways would carry on if they were worked similarly to most of our factories ? Suppose you go down to New Street Station. You want to take a train for London. At present you get in the train and are taken to London in two hours.

Now supposing they operated the railways as they do so many of our businesses. You would go down to New Street. You would want to know when the next train would leave for London. No one could tell you. You hunt up the stationmaster and ask him, and he tells you, " Put your name on the blackboard and when we have enough people to make up a train we will run one." So you put your name on the blackboard, some others do the same, and you figure out how long before there will be enough down to get a train full. Then you find after a long while perhaps that they have got enough for a train. They bring up the train and it is loaded up ready to start.

Then you find that there is no locomotive. They go to look for a locomotive, and when they have got it they find that someone in the purchasing department has bought the wrong kind of coal, because they could get it cheap. Then they have to take the engine back to the shop and put in new furnace bars. You would then perhaps get started, but you would soon stop because somebody had forgotten to put water in the troughs, and you would wait until the pump got going.

Then you would find you would have to change at Rugby, and by the time you arrived there the train for London had gone on because the mayor or some other personage was in a hurry and he had to have precedence. And so on. You would have to wait hours to get another train.

I could multiply these illustrations. I could apply to the operations of the railway those of the average factory. You would get to London finally, of course, but you would not get there in two hours. You would not get to London in ten times two hours as at present.

The railway has a plan. If you want to take a journey you get an A.B.C. or a Bradshaw. You know exactly when you are going, when you will arrive at your prospective destination. It is so dependable that you make appointments accordingly.

There is no reason why factories should not be run on the same plan. It is incumbent on the management to keep control. Management must be always looking ahead, and it means from 35 to 150 per cent. increase in the output of the factory.

Ineffective Co-ordination of Sales and Production

Now the question of co-ordinating the sales and the production. One of the biggest troubles of to-day is that the sales department control the factory. I could tell of instances where the salesmen actually run the factory. They go to the factory and tell the foreman what to do. They tell him that they are in a hurry for this or that particular order, and compel him to drop this and to change about.

The great trouble is that the selling and the productive side of the business are not running together. The head salesman of a factory came to me one day and said : " The factory has got into an awful state. We promised our customers a supply of our new lines, but to-day there is not a single one of them in stock, and there does not seem a chance of getting them into stock." I remarked : " You cannot get what they require in the old lines. Then how do you expect you can ge the twenty-five new lines which you have put on in addition, and which must mean so much loss in output ? " I said to him a few days later : " If you make certain changes in the design, you can figure on a 30 per cent. increase in output, for then the factory can work to better advantage."

The suggested changes were made and the output of the two articles was 29½ tons instead of 17 tons, and the customers were just as well satisfied ; in fact they were better satisfied, because they got the quantities they ordered promptly. And it only meant a very slight alteration which should not have been necessary, because in making the design they never considered the machinery of production.

Inaccurate Costs and Statistics

Then the question of costs and statistics. The chairman of a company complained of the works manager, in fact blamed him because the company was losing money. And this in spite of the fact that the works manager had secured a substantial increase in the output of the factory.

That is a common fault of the chairmen of companies. If anything is wrong they think only of changing the works management. Of course, if they change the management far enough up, it would often serve as a corrective measure.

In this instance it was found, when the system of costing was investigated, that the bulk of the sales was on a line which was sold at less than the cost of manufacture. The sales of this particular article were increasing, and for every lot sold the firm was losing money. They were offering an inducement to the works manager to get more and more production, and if it was increased up to a certain point the length of time the business could remain solvent was purely a problem of arithmetic.

The works management was being censured when the fault was higher up. As a matter of fact, there are less than five per cent. of the manufacturers who know what their products are costing them.

In another firm the managing director had it figured out that the cost of one of his products was a minus quantity. They had put in labour, material and establishment charges, and yet, according to the cost figures, the firm could give the article away and make 4d. a pound profit on it.

The fault with this director was that his costing was wrong in principle. When it comes to a question of costs there are so many people who think that they can ignore principles with safety if the calculations are carried out to enough decimal places.

Now the question of statistics. How many manufacturers know exactly what is going on in their businesses ? If you want statistics you have got to know what is to be done, when is it to be done, and how is it to be done. Then you have to know what was done, when it was done, and how it was done. My experience is that there are very few manufacturers who are in a position to answer those three

questions definitely, but it is the only way you can find out whether waste exists or not.

If you do not know what can be done, if you do not know the exact length of time, if you do not know how it is going to be done, and when it is going to be done, you are not in a position to know just how much waste exists.

Improper Working Conditions

Now as to improper working conditions. Air and light, two of the cheapest things in the world, are not used sufficiently in factories, although they have a very important effect on the volume of work turned out. You can probably get anywhere from ten to twenty per cent. increase in output by improving the lighting conditions at a cost not exceeding one-half of one per cent. of the expenses.

They used to build factories without any consideration of what was going to be done in them. Take an old factory, then a newer factory, and see the difference in the wall area that is in windows. The old factories used to be built with thirty to thirty-five per cent. of glass. It should not be any less than 80 per cent.

Then there is the question of heating and ventilation. If people are going to work well they have to be comfortable; you must see that they can get about; they have to have things arranged in a convenient manner.

Very few factories are built that provide any means of getting material in or out of the work rooms. It may seem strange, in view of the fact that manufacture consists of changing the form or the shape of some material or other. But at the same time they never study how to get it in or how to get it out.

I can tell you a case of a foundry, to show how important the question of handling material is. They handled 168 tons of material for one ton of castings. Although that quantity had to be handled in order to get one ton of castings, there was no provision made for moving it except by hand.

I can tell you another case where five years ago there were 550 men engaged in handling the material in and about a factory, and to-day the whole of that work is done with 55 men and 25 machines.

Now these are records of waste. This entire discussion is a question of waste, and the costs are being added to the cost of the product. All these are wastes for which the management is entirely responsible. It is no use blaming the labour unions or the men for other wastes so long as these wastes exist.

Incompetent Personnel

The last item—" Incompetent personnel." In how many organisations is full consideration given to the selection of people? Investigation shows that there are about 75 per cent. of people in the factory on the wrong jobs, and you can get anywhere from 40 to 50 per cent. increase in output if you put them on the jobs for which they are fitted. The responsibility is with the management when we come to examine it.

The responsibilities of the management are very extensive. The management select and assign work. What are the requirements for that particular job? How many managements know them? They are beginning to consider this question of selection now because of the tremendous wastes involved by refusing to pay attention to it formerly.

This involves not only the requirements for the job, but it involves the study of the methods of doing the work, and when we get down to the study of the methods of doing the work we find it is necessary to educate and to train the people to do the work along these lines.

The study may disclose that a lot of managers and executives are on the wrong jobs, so that you have to start in at the top and not at the bottom.

The study of the elimination of wastes has extensive ramifications. In the management of an industrial concern the advantages resulting from organisation are probably about 35 per cent. The advantages resulting from technical knowledge may be valued at 20 per cent.; the great gain is in utilisation of knowledge, which is the other 45 per cent. We used to be told that knowledge was power. Knowledge is not power. It is the use of knowledge that really matters.

You can have all the records. You can know exactly—you can have the percentage of waste carried out to several decimal places, and all listed and tabulated, but these records will not in themselves eliminate waste.

Technical knowledge does not in itself eliminate waste, and organisation in itself does not eliminate waste. As a matter of fact, over-organisation is more of a hindrance than under-organisation, for the art of management is not equally developed with that of the science of management.

The Art of Management

The science of management has been developed until we know what are the causes of waste and the relative values, but these wastes cannot be eliminated until the art of management has been developed. Now that is the problem of management. The art of management is the thing that is in need of attention, and it is the art of managing people.

If you have the records, the success of the manager is in his ability to get the organisation to work, to get these wastes eliminated. There is no best plan. You do not " manage " material. You do not " manage " the buildings and the equipment. You do not " manage " anything that is incapable of self-determined action. You " manage " people only.

The cure, the means for eliminating waste, is in the better education, the better training of the people concerned in order that they may make full utilisation of their time, of their energy. The best plan, like the best manager, is the one that works most effectively.

STAINLESS STEEL NOVELTIES

Sheffield was the original home of the wonderful material known as stainless steel, which has the property of remaining untarnished by damp or acids. In the same city continuous progress is being made in the manufacture of this material for various new purposes. The latest triumph is the casting of stainless steel—or, perhaps, what is more accurately known as stainless iron—in many complicated shapes. Another development is the production of stainless steel candelabra and similar decorative articles. The castings are particularly useful for bearings which are in contact with superheated steam, as they remain perfectly unaffected under these trying conditions. Tubes and malleable sheets are also made of stainless steel, and fine examples have been turned out of stainless steel wire ropes.

SCIENCE

Conducted by A. H. HAVER, M.I.N.A. & K. S. DICKINSON, F.C.S.

THIS SECTION DEALS WITH THE APPLICATION OF SCIENCE TO INDUSTRY AND PARTICULARLY DEALS WITH APPLIED CHEMISTRY

Combustion and the Production of Fire

How Promethean legends have been explained by the simple action of striking a match, and yet none of the wonders of producing a fire have been diminished.

ONE of the most typical, most familiar, and most important cases of chemical action is that which is observed in the process of combustion or the burning of substances in air. The manner in which the first visible combustion, or fire, was brought about on the earth, whether by some lightning flash, or by the sparks struck from the flints of primitive man; by the rubbing together of dried wood, or by the self-heating of combustible material, will doubtless always remain unknown. But in whatever way fire was first produced, its importance and value were early recognised, as we can understand from the sanctity with which all primitive peoples have endowed the hearth; from the Promethean legend of a boon stolen from, not granted by, the gods; as well as from the later belief of the followers of Zoroaster, that fire is the special abode of divinity.

And even in modern times, although the feeling of reverence or of awe is no longer inspired by a process which can be explained in terms of chemical action, and can be produced at will by the striking of a match, we are not likely to underrate the importance of combustion when we remember that our present-day civilisation, in all its manifold forms of expression, in manufactures, in railway and steamship transport, in artificial illumination, etc., is based on a process of combustion.

What, then, is the explanation of this process of combustion? Not so very long ago, the view was held that the property of combustibility was ue to the presence in the combustible substance of a fiery principle, phlogiston; and that when a substance burns, the phlogiston escapes, leaving behind the ash or calx, as it is called in the case of a metal. Charcoal, which burns leaving practically no ash, was therefore regarded as being almost pure phlogiston. This was the explanation of combustion given, more especially by Stahl, towards the end of the seventeenth century; and it was not till a hundred years later that the "phlogiston theory" was finally overthrown by the French chemist Lavoisier, who died in 1794, a victim of the guillotine, in the troublous times of the French Revolution.

The long life of such an erroneous theory as that due to Stahl may be attributed to the fact that chemistry was, at that time, still largely a qualitative or descriptive science, and it was considered that form rather than weight was the characteristic property of substances. The balance, of course, was known and used, but its importance was not fully appreciated; so that when it was found that the products of a combustion weigh more than the original combustible substance, the upholders of the phlogiston theory sought to defend their position by identifying phlogiston with the principle of levity. The escape of the principle of levity from the body, left the body heavier.

Much as we may be inclined to smile at such an explanation, we must remember that the phlogiston theory served usefully its day and generation, and satisfied even the modern requirements of a theory, in that it gave an explanation of combustion which satisfied men's minds at the time, and also inspired a large amount of fruitful investigation. Who can say that even some of our most cherished theories may not be considered by the unthinking, a hundred years hence, to be equally worthy of derision? The phlogiston theory, however, long outlived its usefulness, and the tenacity with which it maintained itself is an instructive illustration of the difficulty which most minds have of freeing themselves from the authority of a long-held theory; and it conveys a lesson, which is not unnecessary even at the present day, that a theory from being a helpful guide may readily become an oppressive tyrant. As Liebig wrote many years ago, after having himself been a victim of the misfortune to which he refers: "No greater misfortune could befall a chemist than that of being unable to shake himself free from the power of preconceived ideas, and, yielding to the bias of his mind, of seeking to account for all phenomena which do not fit in with these ideas by explanations which have no basis in experiment."

But the irresistible force of facts was gradually increasing, and after the discovery of the gas oxygen by Priestley and by Scheele, in the year 1774, Lavoisier was able to put forward a new interpretation of the process of combustion of substances in air; and with that interpretation, modern chemistry was born.

Air is essentially a mixture (not a compound) of the two invisible gases, oxygen and nitrogen. The former of these, constituting about one-fifth of the air by volume, not only allows combustion to take place, but promotes it to such an extent that a

glowing splint of wood, when immersed in the gas, bursts into flame, and the substance phosphorus burns with dazzling brilliancy. Oxygen is very "active," and combines with practically every other element, the process of combination being known as oxidation. Nitrogen is, however, an inert gas, and even the most brightly burning phosphorus is extinguished when introduced into it. The explanation of combustion is thus not far to seek, and is to be found, as Lavoisier proved by the actual weighing of the substances, in the chemical combination of the burning substance with the oxygen of the air. The process of combustion, in other words, is a chemical reaction, a process of oxidation of the combustible substance by the oxygen of the air, which is accompanied by the emission of heat and light; but a flame is formed only when the burning substance is a gas at the temperature of the combustion. The nitrogen of the air takes no part in the process, but merely acts as a diluent which moderates the vigour of the combustion.

But if combustion in air is a chemical reaction between the combustible substance and the oxygen of the air, why does the former not take fire when exposed to the air? We may allow the coal gas to escape from the burner, or a candle or piece of wood or coal may be left exposed to the air, or even to pure oxygen, without any apparent change taking place; and in order that they shall exhibit the phenomenon of combustion, that is, in order that they shall undergo the process of oxidation, or combination with oxygen, with production of heat and light, it is necessary to heat the materials up to a certain temperature, called the ignition point of the substance. Combustion then goes on of itself. The explanation of this fact is that the velocity or vigour of every chemical charge is increased by elevation of the temperature. At the ordinary temperature, the oxidation of the candle or the coal takes place so slowly that no change is apparent even over long periods of time. If, however, the temperature of the combustible material is raised, the rate at which it reacts with the oxygen of the air rapidly increases, and consequently the production of heat which accompanies the reaction also rapidly increases, until, at a certain point, the ignition point, the reaction takes place with such rapidity that the heat which is produced by the process of oxidation is sufficient to raise the substances to incandescence and also to maintain the burning substance at a temperature above the ignition point. The process of combustion is thus enabled to proceed continuously.

On the other hand, if the burning substance is cooled sufficiently, the temperature is lowered to below the ignition point, and so the combustion ceases. A simple experiment which can be carried out by anyone will serve to demonstrate this important truth. If we hold a piece of metal wire gauze at a distance of half an inch or an inch above a burner from which coal gas is issuing, and if we then apply a light to the gas above the gauze, we shall find that the flame of burning gas is arrested by the gauze and does not pass through to the burner; for the wire gauze conducts the heat of the flame away so rapidly that the temperature is lowered to below the ignition point of the gas. Only after the gauze has become quite hot does the gas below the gauze become ignited. Similarly if the gauze is brought down on a flame of burning gas, the flame is extinguished at the gauze. The gas itself, however, passes through, as can be shown by bringing a light to the upper surface of the gauze, when the gas will take fire.

The cooling power of wire gauze received, early last century, an application of the highest importance in the miner's safety lamp invented by Sir Humphry Davy. This lamp has undergone a striking change and marked improvement since the time of its first invention, and the modern safety lamp shows little sign of the means whereby safety is secured. But on careful examination it is seen that all the holes through which air can pass to the flame, or the hot air and products of combustion can pass out, are protected by fine wire gauze. Although, therefore, the combustible gas, the "fire-damp," can pass through this gauze and can burn inside the lamp, the flame cannot pass through the gauze and be communicated to the explosive mixture of fire-damp and air in the mine.

Warning of the presence of the dangerous fire-damp is given to the miner through the luminous flame of the lamp becoming crowned by a "cap" of pale blue flame. The greater the amount of fire-damp, the larger is the cap.

The process of combination with oxygen, which, as we have seen, is the essential feature of the process in air, may, however, go on appreciably even at temperatures below the ignition point. Thus, when metallic iron is exposed to moist air, it rusts. This rust is oxide of iron, a compound of iron and oxygen; and the process of rusting is therefore a process of oxidation, a process of combustion, against which it is necessary to protect, by paint or other means, all iron structures exposed to the air, if we would have them last. This slow combustion, as it is termed, can be demonstrated more strikingly with the metal aluminium, which has a greater affinity for oxygen than iron has. When finely-divided aluminium is heated in the air, for example, when aluminium powder is blown through a flame, it burns with a very bright light; but when exposed to the air at the ordinary temperature, the metal remains apparently unchanged. As a matter of fact, it rapidly combines with the oxygen of the air, but the coherent film of oxide which is formed on the surface protects the metal from further attack, and therefore no change is apparent. But let us now coat the surface of the metal with mercury. By this means a liquid amalgam or alloy of mercury and aluminium is produced, and the formation of a coherent film of aluminium oxide is thereby prevented. The aluminium is consequently no longer protected from the continued action of the oxygen of the air. In this case we observe that the aluminium undergoes oxidation quite rapidly, the oxide forming a moss-like growth on the surface of the metal. The heat which is produced by the oxidation, although quite marked, is dissipated so quickly that the temperature does not rise to the point of incandescence, and so no light is seen.

Processes of slow combustion, or combustion unaccompanied by the emission of light, are going on continually within our bodies, and are the source of the heat by means of which the temperature of the body necessary for health, is maintained. When air is drawn into the lungs, the oxygen passes or diffuses through the thin walls of the blood vessels, and is absorbed by the blood, whereas carbon dioxide passes from the blood into the air-spaces of the lungs and is expelled in the expired air. The oxygen is carried by the blood to all parts of the body, and oxidises or burns the tissues and assimilated food materials with production of carbon dioxide and water, the former being

(*Continued on page* 628.)

TRANSPORT

Conducted by "M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH THE MANAGEMENT AND CONTROL OF RAILWAYS

The Modernisation of Passenger Railway Stations

BY F. BUSHROD, O.B.E., AND J. F. S. TYLER

I HAVE assumed that it was the intention of the Council, when choosing this title for the paper it is my privilege to read to you to-night, that I should lay before you the practice and purpose underlying the modern passenger stations that have been constructed, and the modernisation of the larger stations of old standing, such as Waterloo.

To understand clearly the issue before us, it would be well to cast our minds back to the early days of railways, and review what our railway forefathers did in the way of designing and constructing passenger stations.

Many of the early terminals remain to-day, with, of course, additions, largely as they were originally constructed, and bear, it seems to me, evidence that their designers or authors thought that passenger business in their days would be a very much bigger business than it proved to be; or, alternatively, that they had little regard or appreciation for the economics of railway administration.

The latter point I mention because we shall come to it again.

In the matter of old passenger stations, it is very noticeable, as you go about the country, the number that exist almost as originally designed, as compared with goods yards. The latter seem to have been altered and enlarged out of all recognition. Is it because the very large goods traffics that the railways eventually handled were never dreamt of, or is it that the expected passenger business was never realised in the days of the railway giants?

To come more particularly to the subject before us, the disastrous war, commencing in 1914, has undoubtedly had a very prejudicial effect upon our "modernising work," and it will be very many years, I am afraid, before the opportunities thus lost can come again.

Not only did the great war retard the new works of railways, but it did, and must have, for many years to come, a big effect upon design.

It was not many years ago that a railwayman who talked of and worked for really economic administration, was looked upon as a very objectionable person.

Wages were low, the cost of buildings not great, and traffics plentiful, there was little or no competition by outside agencies, and, for any but the shortest distances, passenger traffics were sure to come to the railways.

All these factors undoubtedly influenced passenger station design. Now we have entirely different conditions. We are faced with road competition, wages are high, new works are costly, and we have consequently to design stations so that we can do our work with a minimum of expense and with the maximum of expedition.

Types of Stations

It is well to remember the number of types of stations; and, after having settled upon the site for a new or reconstructed station, a matter in which the relation of the site to the town or district to be served, the gradient of the lines, and such like governing factors have to be taken into account, consideration has then to be given to a great many other factors calculated to influence design and lay-out, *e.g.*:—

Length and type of platforms and covering.

Position of facing crossings and cross-over roads.

Sites of water columns.

Horse and carriage docks.

Situation and design of offices.

Refreshment rooms.

Situation of staff mess rooms.

Arrangement of entrances and exits.

Position of footbridge or subway.

Sites for weighing machines.

Lifts (if necessary) for luggage and parcels.

Position of train indicators.

Accommodation for storage of cycles.

Direction boards and signs—ordinary and illuminated.

Sites for bookstalls, telephone call boxes, ticket collectors' shelters, clocks, first-aid and emergency chests, fire appliances, lamp room, shops (if any), or possibly post office, bank, etc.

Approach and station yard, with cab rank, bench (if necessary) for unloading luggage (with awning over), sites for estate offices, coal order office, motor car sheds, etc.

Even this list does not exhaust the possible requirements, which naturally vary according to the conditions, local and otherwise, which obtain, but may be taken as setting out generally the variety of matters for which regard may have to be had. Other points of detail of construction must necessarily arise, and will be dealt with as we proceed to the consideration of the plans which will be put before you.

Arrangement of Station Offices, etc.

In endeavouring to secure economic working at a station, much depends upon the arrangement of the station offices in relation one to another, and to the station generally, coupled, of

course, with any special conditions which may obtain at a given place. One of the best results can be achieved where a road bridge passes over the railway at a station, and advantage can be taken to construct the front of the station in a position facing the road, the booking hall, booking office, parcels office, and other offices to which the public require frequent access, being placed in proximity to the entrance, leaving the platforms free of any buildings except rooms for the use of the staff, waiting room, and lavatories. In other instances, where a platform is contiguous to a station yard or approach, the first consideration is to place the booking hall in such a position as to form the main entrance, and thus ensure passengers an opportunity of obtaining tickets before proceeding to the platform. Station master's office should be erected, as far as possible, where a good general view of the station can be obtained. Except at very large stations, the parcels and cloakroom business can be carried on in one office, or, if not, these offices can be erected adjacent to, and, for preference, connected with each other. Similarly, at small stations, the booking, parcels and cloakroom business can be handled in one office, and at stations (usually in outer suburban districts) where the number of cycles deposited warrants separate provision, the cycle store should adjoin the parcels office. Inspectors, foremen, porters, and other members of the platform staff, should have their rooms located where they can be readily reached; public enquiry offices need naturally to be readily accessible to the public; and care bestowed on the selection of sites for train indicators and direction boards will be amply repaid by the saving of time otherwise occupied in dealing with multitudinous enquiries. Lamp rooms should, on account of risk of fire, be erected on sites isolated from other buildings. Of late years, a demand has sprung up for telephone facilities for the public, also for opportunities for shopping at large and much-frequented stations, and there is undoubtedly much to be said for the idea, in moderation. Lastly, in constructing station premises, due regard must be had to the requirements and recommendations of the Ministry of Transport, bearing in mind that any new station has to be inspected by an officer of that department, and that the Ministry have power to withhold their approval and thus automatically suspend the bringing into use of any work of the kind in the event of their requirements not being complied with.

Careful thought must also be given to the relative position of the various offices from the point of view of combination of work, as although the traffic may require and justify the employment of separate staffs during the busy part of the day, you may be able to combine two or more jobs during the early morning or late evening and on Sundays. In view of the heavy cost of Sunday labour, this point requires to be borne well in mind, and affords a fruitful field for the economical designing of new station buildings.

Loco. Depots and Carriage Sheds—Situation in Relation to Station

Whereas a few years ago, when drivers and train crews worked an unlimited number of hours, it was sometimes economical to provide an engine shed or carriage sidings away from the terminal station, but the reduction of hours of labour, the payment for all overtime, has brought into existence a new economic factor compelling the companies to look closely into the cost of light running to and from engine sheds and berthing of coaching stock, and, in fact, it can be laid down as a fundamental principle that, where your traffic commences or terminates, there also should you berth your engines and coaching stock. Of course, there may be local conditions which compel you to modify in practice the principle here laid down, such as in London, where the possibility of getting the land is remote, and owing to the price, prohibitive.

Standard Type of Design

The idea has long been in my mind that it would be very useful if a few traffic and engineering gentlemen of great railway experience could be brought together to discuss and design types of stations on standard lines. To-day, nearly every railway has a different practice, and whilst this will probably be considerably modified by the new grouping arrangements, standard designs and practice would lead, I am convinced, to considerable economy.

Influence of Electrification of Steam Lines on Passenger Station Design and Working

Conversion of lines from steam to electric traction, followed by the introduction of a rapid service at regular and frequent intervals in substitution for comparatively slow and infrequent steam trains, involves consideration of station design from a new aspect. Stations on old-established railways have been constructed and re-constructed during a period of nearly three-quarters of a century to meet the requirements of steam traction, and their equipment in many respects does not lend itself to the general "speeding up" of traffic movement with electric traction.

With the growth of passenger traffic, particularly in suburban areas, there came about a gradual lengthening of platforms to accommodate long steam trains of as many as eighteen or twenty coaches. Under electric traction, with shorter and more numerous trains, these long platforms are unsuitable. Even with carefully placed and easily understood stopping marks, passengers have a tendency to spread themselves along the whole length of the platform during the intervals between trains, and time is lost waiting for the passengers to make their way to the point where the train stops.

The location of platform entrances and their protection require closer attention than was given under the more leisurely steam working. The placing of entrances at extreme ends of platforms brings about uneven loading of trains which is very noticeable when there are two or three consecutive stations having the entrance at the same end.

It will generally be found that the best position for the opening on to the platform is a point about the centre of its length, so that passengers can debouch right and left when entering. Owing to the risk involved in passengers attempting to enter rapidly-accelerating electric trains in motion, it is essential that entrances should be protected by an easily closed barrier, and that this barrier be placed as near the platform as possible. If passengers are allowed to reach platforms directly from long passages or flights of steps, it is difficult to prevent them making a rush for a moving train when they catch sight of it, possibly with disastrous results.

For similar reasons, exits from waiting rooms and lavatories require to be carefully placed.

Whilst speaking of waiting rooms, it is well to point out that the introduction of an electric train service running every few minutes obviates the necessity for providing such ample waiting room accommodation as it was formerly the custom to afford.

Platform covering should, however, be ample, especially from the point of view of even loading of trains and avoidance of delay thereto, as an exiguous platform shelter on a wet day leads to the congregation of a mass of passengers at one point, all attempting to crush into one or two carriages.

The timing of electric trains permits of only very brief stoppages at stations, 25 seconds being the usual allowance, and it is, therefore, essential that everything possible be done to avoid causing passengers to have any hesitancy in entering or alighting from trains, and to expedite the handling of luggage, etc. In this connection, careful attention is necessary to the following details of station design, namely :—

(1) Ample platform width free from columns, lamp posts and other similar obstructions.
(2) Platforms of footboard height and having good surface for movement of barrows, etc.
(3) Provision of separate entrances and exits at stations where traffic is heavy.
(4) Provision of adequate booking office facilities.
(5) Clear and distinct platform and train indicators, direction boards, station name boards, etc.
(6) Adequate lighting of platforms and illumination of station name boards.

Where power is taken from conductor rails, it is, of course, necessary to cut the latter at points where timbered crossings are provided for passing luggage barrows, etc., from one platform to another. Such crossings are a source of risk where there is a frequent and rapidly accelerating train service, and station design should provide for their elimination, so that, wherever possible, traffic to or from one platform can be dealt with without crossing the rails on the level.

Some Experiences with the Bock Roller Bearing

A plain write-up of an important invention.

OWING to the keen interest which railway engineers and designers are showing in British Bock bearings, as applicable to axle boxes of rolling stock, it is thought that it will be of some interest to quote certain facts and figures known about the use of the bearings on trucks and passenger coaches running in the United States of America.

Bock bearings are fitted on the Stanley steam car manufactured by the Unit Railway Company, Boston, Mass. The car weighs 60,000 lb. without load. The average load is fifty persons, but they have carried as many as one hundred. There is also a fairly large package compartment behind the boiler in the front which carries luggage.

The oldest car has been in service for four years, and is in operation on the White River Railroad, on a branch line of the Vermont Central running about twenty miles up into the mountains.

The bearings were installed in this car in the spring of 1919. It is not possible to give the exact mileage of this car, as it is sometimes laid up for repairs, and sometimes cannot run in the winter, due to ice and snow on the tracks. However, its schedule calls for two round trips per day, which would make a total of eighty miles daily.

White River Railroad

The White River Railroad is simply a branch line, its principal reason for existence being freight haulage, and, as a consequence, its trackage is in miserable shape. The railbed is very rough, the rails are warped, and the entire line is full of curves and grades, so that when the car is running at full speed there is a great deal of sway, and consequently severe thrust load thrown on the bearings, also many shocks are transmitted to them due to the bad condition of the rail joints.

The maximum speed of the car is probably from 45 to 50 miles per hour on the level, but in coasting down grades sometimes this is exceeded. The coasting ability of the car is remarkable, and is demonstrated by one man being able to push it alone for several feet.

One of the demonstrations which this Company use is to reverse the car back and forth by use of throttle, not using the brake to retard motion. They do this on a length of track not over three hundred feet long. They attribute, in part, their ability to do this to the use of roller bearings in their wheels.

These bearings were inspected in April of 1922, and no signs of wear were apparent on any of the load-carrying surfaces.

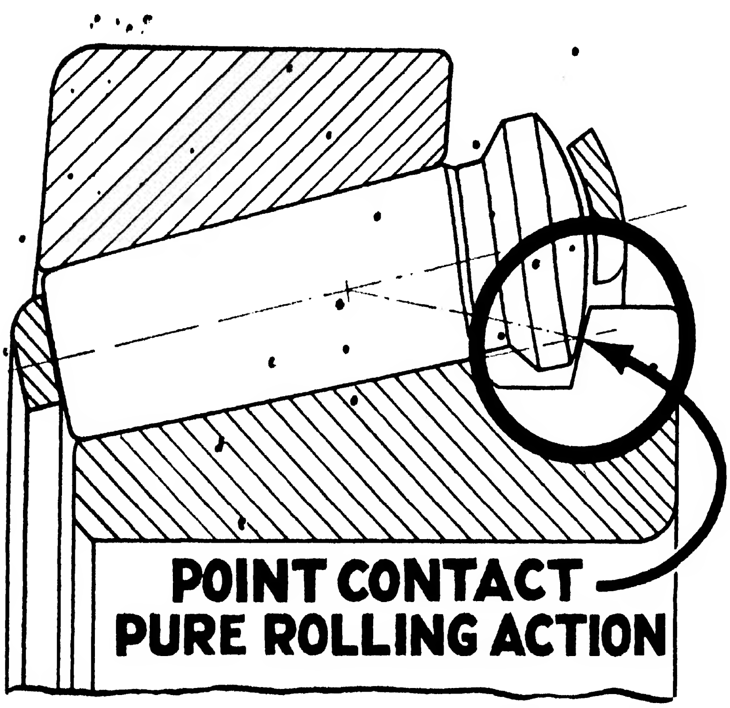
Several of the United States arsenals are using this equipment for haulage and switching in their yards. Their experience, as reported, is that Bock bearings are the only bearings that would stand up to the service, and, as a consequence, the Ordnance Department of the United States Army has specified these bearings on trucks used on rails.

A report made of the operating conditions on the Manhattan Railroad Company in May of 1922 reads as follows :—

"These railroad cars are fitted with cast steel wheels and demountable steel flange tyres. Two of the cars are used between the city of Manhattan and Junction City, a distance of about fifteen miles.

The cars have replaced the city street cars, and also the inter-urban cars running between the above two points.

The equipment was installed about January, 1922. The rails over which the street cars run are in very bad condition, as nearly all the joints are



low, forcing the cars from side to side, subjecting the wheel bearings to very severe shock thrust loads.

The curves on the city tracks are 45 ft. radius, and as the wheel base of the truck is 156 in., there is considerable strain on the bearings when turning these curves."

British Bock Bearings Ltd., have a modern factory located at Cornwall Street, Glasgow, Scotland, where special automatic machinery is employed to produce the various component parts of their bearings which are finished to a degree of accuracy well within the S.A.E. limits.

All engineers who may be interested in the service of British Bock adjustable taper roller bearings for railway coaches or trucks should write for drawings to show the application, together with any other particulars necessary.

An important feature is the pure rolling action on all load carrying surfaces, and the entire absence of friction, which results in cool bearings, also low cost of maintenance, plus low fuel consumption and greater tractive power of locomotive.

Combustion and the Production of Fire

(*Continued from page* 624.)

then conveyed by the blood back to the lungs, and so got rid of.

The presence of carbon dioxide in expired air is readily shown by blowing through a tube into clear lime water (a solution of slaked lime in water). The liquid very speedily becomes turbid owing to the separation of insoluble carbonate of lime, formed by the combination of carbon dioxide with the slaked lime. The production of turbidity with lime water is used as a test for, or method of, detecting the presence of carbon dioxide.

In the processes of putrefaction and decay, also, we have examples of slow combustion, in which animal and vegetable material is oxidised by the oxygen of the air, with the co-operation of various micro-organisms; and efficient aeration, as in a rushing and tumbling stream, is an excellent means of purifying water from all kinds of organic and bacterial contamination.

Under favourable conditions, the process of slow combustion may pass into rapid combustion with production of light. For, if the heat which is produced by the combination of the oxygen with the combustible material is prevented from being dissipated, the temperature will go on rising gradually, and as the temperature rises, the vigour of the combustion increases. More and more heat, therefore, is produced in a given time, the temperature rises more and more rapidly, until, finally, it reaches the point at which light is emitted. The slow combustion passes into rapid combustion, and the combustible material takes fire without the application of external heat; in other words, it undergoes spontaneous combustion. In this way arise, for example, the so-called "gob" fires, in spaces from which coal has been removed, and where coal dust and fine coal remain behind; so also may fire break out in coal bunkers and in other confined spaces in which combustible matter, like oily cotton waste, is stored without proper ventilation. Such spontaneous combustion will, of course, take place with special readiness in the case of readily inflammable substances, or substances which have a low ignition point, such as phosphorus. Thus if this substance is dissolved in the liquid known as carbon disulphide, and if the solution is then poured on a sheet of filtering paper, or thin blotting paper, the carbon disulphide soon evaporates and leaves the phosphorus on the paper in a finely divided state. The oxygen of the air rapidly unites with the phosphorus, and the heat which is thereby developed soon raises the temperature to the ignition point of the phosphorus, and rapid combustion sets in.

Warren Trailers

How the use of trailer vehicles — in conjunction with the use of power vehicles — can reduce the cost of transport.

ONE of the most urgent and universal problems of the present time is, perhaps, the reduction of transport costs. It is a problem bristling with difficulties, but those depending upon road transport are in the fortunate position of having at their disposal a definite and proved method of effecting a step in this desirable direction.

We refer to the use of trailer vehicles in conjunction with the existing power vehicles. Needless to say, numbers of transport users are fully alive to the advantages of such a course, but there are many who have still to appreciate the benefits to be derived from the intelligent use of trailers.

There are folk who mistakenly imagine that almost any vehicle can be adapted as a trailer, but a little thought should convince them that the same service is demanded from a trailer chassis as from a lorry chassis, and that the construction of the one is as important as the other. It is therefore imperative that to get really satisfactory results, a well-designed and soundly constructed vehicle should be adopted.

Warren Trailer with the Fordson Tractor

Such a vehicle is represented by the Warren trailer, which is described below. This trailer is designed and constructed on the same lines and with the same care as a lorry chassis, and may be consequently relied upon for continuous service and low upkeep costs.

It may not be out of place to enumerate the leading advantages obtainable by the use of trailers, and we would here say that the theme of the present article is the independent trailer, and our remarks must not be taken as referring to six-wheeled vehicles or such like modifications of the trailer pure and simple. Such vehicles have their own sphere of usefulness, which it is not the purpose of this article to consider.

First of all we have in the ordinary steam or petrol lorry a considerable reserve, under most circumstances, of tractive effort. The trailer enables us to utilise this by adding to the load carried on the lorry itself anything from 100 per cent. in the case of steam and the more powerful petrol vehicles to at least 50 per cent. or 60 per cent. in the case of the lighter petrol lorries.

It is worthy of note that the increase of fuel consumption is not in proportion to the increase of load, a matter of some importance with the more expensive fuels. Messrs. Warren find that the gross ton mileage per gallon with petrol is increased by anything from 15 to 25 per cent. when their trailer is used.

Added to this, the extra load is carried without any increase in the wages bill, while loading and unloading of the trailer can be effected without incurring demurrage on the lorry.

This last feature becomes more pronounced when the hauling vehicle

Warren Trailer Chassis

With Renault Tractor

Warren Pressed Steel Disc Wheel

takes the form of a separate tractor. It not infrequently happens that the distance between loading and unloading stations is comparatively short, which means that the running time is a very small proportion of the working day. When motor vehicles are used, this means that capital charges are enormously increased through the power plant standing idle for such a large proportion of its time.

The use of one of the small and inexpensive petrol tractors, now readily procurable, in conjunction with several trailers, confines this demurrage to the trailers, which, costing each one-fourth or one-fifth of the amount which must be expended on a lorry, materially reduces the expense in this direction. For the same capital outlay, also, the goods can be shifted much more rapidly, two or three times the number of journeys being accomplished per day by the tractor as compared with the lorry.

The Warren trailer is built entirely of steel, the frame being of a substantial rolled section fitted with two massive cross members, and well braced, to equally distribute the drawbar pull.

The springs are wide and of a good length, mounted on substantial pins at the forward end, and sliding on large bearing surfaces at the rear end.

The axles are of square section high tensile steel, having a tensile strength of 40 tons per square inch, and provided with plain bearings with phosphor bronze floating bushes. These bearings are of unusually large dimensions for the load.

The wheels are especially worthy of notice, and are a speciality of Messrs. Warren's. They are constructed of sheet steel, and are a notable example of press work. The rim and the main disc are pressed up in one piece, and additional strength is provided in the form of a second pressing which is forced into the main plate and riveted thereto. This second plate affords support for the overhung portion of the rim, and enables the required thickness to be provided at the hub to give the wheel lateral strength. This construction provides a wheel in which there are no riveted joints under any high stress, and the wheel should prove practically unbreakable.

The steering is effected on the Ackerman principle, which, as is well understood, affords greater stability and more positive control than the turntable method. The better control is particularly noticeable when reversing.

A further advantage obtainable with the Ackerman steering is that the height of the frame can be kept much lower, a distinct convenience when loading.

Ample braking power is provided, the brakes being of large diameter, and of the internal expanding pattern. Each rear wheel is provided with a heavy pressed steel drum, upon which cast-iron shoes operate. These are actuated by means of steel cables connected to a compensating bar mounted beneath the drawbar king pin. This compensating bar is carried on a substantial lever to which the actuating cable from the towing vehicle is attached. The function of this lever is to afford a true and direct pull on the brake cables under all circumstances, so that the brakes are just as effective whatever the angle of the drawbar may be.

A screw gear is provided at the rear end of the chassis, by means of which the brakes may be applied by hand. This is operative whether the trailer is attached to another vehicle or not.

The Warren chassis is a carefully standardised article, and all parts are interchangeable. The design is well thought out, and it would appear that these vehicles should fulfil all but the most unusual requirements.

The leading dimensions of the three models at present being turned out of the Warren factory are as below.

Messrs. Warren are able to quote attractive prices for chassis packed and delivered to foreign ports, and issue some very interesting literature which is worth enquiring for.

We understand that they are prepared to grant a limited number of agencies which should be well worth the attention of dealers.

	1 ton	3 ton	5 ton
Wheelbase	6' 0"	6' 6"	7' 6"
Track	5' 0"	5' 6"	5' 6"
Height of frame, loaded	2' 1"	2' 7"	2' 8½"
Height of frame, unloaded	2' 3"	2' 8½"	2' 10"
Width of frame	3' 0"	3' 4"	3' 4"
Length of frame	10' 0"	10' 6"	11' 6"
Depth of frame	3"	5"	5"
Weight of chassis (approx.)	9 cwt.	22 cwt.	23½ cwt.
Weight allowance for body	8 cwt.	13 cwt.	15 cwt.
Tyres ... ... mm.	75 × 750	110 × 870	120 × 900
Rim diameter ... ... ,,	628	720	720
Length of springs	3' 0"	3' 6"	3' 6"
Width of springs	2"	3"	3"
Diameter and width of internal expanding brakes	8" × 1½"	14" × 2"	14" × 2"
Turning circle diameter	24' 0"	27' 0"	30' 0"
Minimum clearance under axle	11½"	12"	12½"
Overall width over hub caps	5' 9"	6' 6½"	6' 6½"

Twelve New 180-ton Passenger Locomotives

For the New York, New Haven and Hartford Railroad

By W. J. CLARDY,

General Engineering Department, Westinghouse Electric and Manufacturing Company

These locomotives, of the 2-6-2 + 2-6-2 type, will permit 100 per cent. electric passenger service. One locomotive, capable of hauling 900-ton trailing load —twelve Pullman cars between Grand Central Terminal and New Haven in ninety-nine minutes. Schedule speed of forty-four miles per hour.

THE New York, New Haven and Hartford Railroad electrification is the most comprehensive in the world, and embodies all classes of service on one of the foremost truck line railroads. The main line between New York and New Haven, a distance of 72 miles, is an outstanding example of what can be done by electrification on a congested four-track section with extremely heavy freight and passenger traffic. There are almost 600 miles of electrified track, including some of the busiest main line and yard trackage in the world. Yards at Oakpoint and Westchester are served entirely by electric switcher locomotives.

The present electric motive power consists of 106 Baldwin-Westinghouse locomotives, 52 for passenger, 38 for freight, 16 for switcher service, and 35 Westinghouse equipped multiple-unit motor cars. The first 41 passenger locomotives, placed in service in 1906 and 1908, are the 2-6-2 type, and weigh 102 tons complete. The last five passenger locomotives were built in 1919, and are the 2-6-2 + 2-6-2 type, weighing 180 tons complete. Sixteen 80-ton 0-8-0 type switcher locomotives were placed in service in 1912, and thirty-six 110-ton 2-8-2 type road freight engines in 1912 and 1913. The first of the 35 multiple-unit motor cars were operated in 1909, and the last eight cars went in service in 1922. These cars range in weight from 84 to 91 tons complete with all equipment (no load), and are really locomotives, as each motor car is capable of hauling two trail cars.

In 1916 and 1917 a very complete study was made of the traffic requirements to determine what type of motive power was best adapted for the service. The original types of freight and switcher locomotives were considered suitable for handling the continued increase in this class of traffic. The first passenger locomotives which were built were satisfactory, except as to capacity. They had been in service only a few years when the railroad began to replace the light 40-ton wooden coaches with steel cars of 62.5 tons weight, having only about 15 per cent. greater seating capacity for 58 per cent. greater car weight. At the present time these locomotives have to be double headed 80 to 90 per cent. of the time, and even at that do not have capacity to handle many of the heavier trains. With so many heavy trains in operation it is desirable to have a locomotive that can handle them without double heading. For these reasons a new locomotive of the 2-6-2 + 2-6-2 type was designed, which is capable of handling all of the heavy passenger trains. Five of these locomotives were purchased and placed in service in 1919.

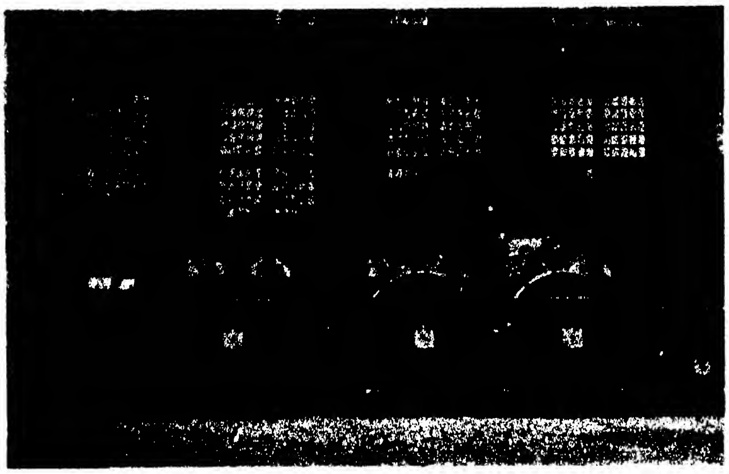
Recently twelve new 180-ton Baldwing - Westinghouse passenger locomotives were ordered, and are now being built. These will be identical to the five passenger engines placed in service in 1919, except for some refinements in minor details. These engines are the 2-6-2 + 2-6-2 type, equipped with six twin 409 C-2 Westinghouse motors, and will operate from a 11,000-volt. single-phase trolley or a 650-volt direct-current third rail. The gear ratio will be 25 to 89 on 63-inch drivers, and each engine will have two pantagraphs and four third rail shoes for current collection. The weight complete will be 180 tons with 122 tons on drivers.

The new locomotives will rate 2,016 h.p., and will develop a tractive effort of 23,200 lb. at 32.6 m.p.h. The continuous rating is 15,800 lb. tractive effort at 39.4 m.p.h. The engines have a high speed rating of 2,424 h.p. and develop this rating at 45.5 m.p.h. The tractive effort is 19,900 lb. A maximum momentary tractive effort of 52,500 lb. is available, and the normal accelerating tractive effort is 38,200 lb. A maximum speed of 66 m.p.h. may be attained with safety.

In designing the passenger locomotives for the New York, New Haven and Hartford Railroad, there are always two factors which have to be given primary consideration. All passenger locomotives are limited to a maximum weight of 181 tons complete with all details, including sand, water, oil and crew. This restriction is imposed on account of the Park Avenue Viaduct in New York, over which passenger trains run when entering the Grand Central Station. The locomotives must be designed for direct-current operation from a 650-volt third rail to permit running on the tracks of the New York Central. This, of course, complicates the control apparatus.

The mechanical parts of the engine weigh approximately 175,000 lb. An interesting feature is the locomotive frame, which is a one-piece steel casting for each half of the running gear. This means two frame castings per locomotive, and simplifies the construction of the engine. They are the largest integral castings ever made for a locomotive, and each casting weighs 18,000 lbs. Operating officials of the railroad have been well pleased with this type of frame, and consider it an insurance of low mechanical maintenance.

The quill drive and details are the same as on the present locomotives, and this type of flexible drive has



Running Gear of present New Haven Locomotives

proved very successful. It is the twin motor type, and is fitted with a single gear meshing with two pinions, one on each armature shaft. The frame of the motor includes two integral bearings carrying a hollow shaft or quill, which surrounds the driving axle. Sufficient clearance exists between the axle and the quill to permit the axle to accommodate itself freely to track irregularities. At the end of the quill, a gear is mounted, meshing with the motor pinions. At each end of the quill are bolted six castings, each gripping one end of a helical spring located between the wheel spokes. The other end of each spring is gripped in a casting which is bolted to the driving wheel.

The 409 C-2 twin motor rates 336 h.p. at 275 volts. for one hour, and 276 h.p. continuous at the same voltage. The speeds at these ratings with 25 : 89 gear ratio and 63-inch drivers are 32.6 m.p.h. and 36.4 m.p.h. respectively. A maximum of 357 volts may be applied to each motor armature when the trolley potential is 11,000 and the locomotive is operating on the highest speed notch of the controller. The motors are the series commutator type with a resistance load winding in the armature, and have compensating windings. This type of motor has proved very successful both on the New York, New Haven and Hartford and on other single-phase electrifications.

The twin motor really consists of two complete motors with a common frame, thus making a permanent double unit. This permits the most efficient utilisation of the limited space available for motors and gearing, and gives a more balanced design. A twin motor weighs approximately 13,000 lb., including bases, axle caps, axle bearings, dust guards, commutator lids, and gear cases. Each motor armature shaft has a pinion, and two pinions are in mesh with the gear for one pair of drivers, transmitting the power to the wheels through the flexible quill drive. The twin motor permits the use of a gear with a narrower face than could be used with a single motor of equal capacity, since power is transmitted to the gear at two points. Consequently the gear requires less space, and leaves a considerably greater length available for the active iron of the armature.

The A.C.-D.C. control equipment is the Westinghouse unit switch, pneumatically-operated type duplicate of that now in service. The entire control of an engine is handled by 28 switches, which is a real achievement when it is considered what is required of the engines. This is accomplished by connecting the motors in four permanent groups of three armatures in series. The switches are arranged in three groups: motor switches, transformer switches, and resistance switches—which assists in simplifying the control. The maintenance of the switches on the five engines now in service is practically negligible.

There are three starting and nine running notches obtained by means of voltage taps on the transformer. The locomotives have three preventive coils, which are used when accelerating on alternating-current. Nine frames of grids are provided for direct-current acceleration. The current per locomotive during acceleration is limited, and is indicated by the ammeter. The controller is "notched up" at a rate that does not permit exceeding the maximum current limit for the locomotive.

Series-parallel control is not provided for direct-current operation, as sufficient speed can be obtained when three motors are connected in series. Series-parallel operation would complicate the control, and the gain in efficiency is negligible. A field shunt, which is effective on the last controller notch, gives the speed that is necessary on the D.C. zone.

The air blast transformer weighs 15,300 lb., and rates 2,100 kv.a. It has the necessary low tension taps for accelerating the locomotive and supplying power to the auxiliary apparatus. The storage batteries (used on alternate days) provide energy for operating the control switches, and a motor-generator set charges the batteries. The blowers

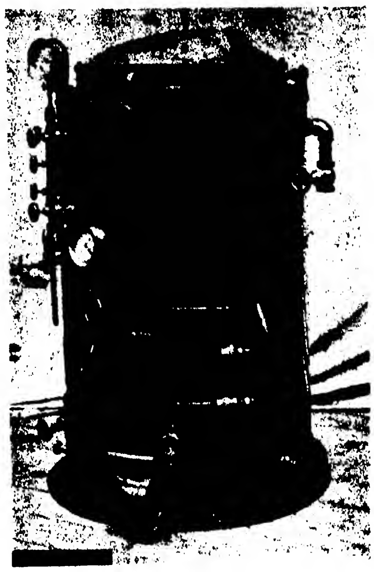
One of the 180-ton Locomotives

are supplied to ventilate the transformer and main motors. There are two air compressors included with the air brake equipment, each having a 60 cu. ft. displacement. The blower and compressor motors are identical, which simplifies maintenance.

An important feature of the locomotive is the train heating equipment. Each locomotive is equipped with oil-fired flash boilers, and the necessary oil and water tanks. The boiler has sufficient capacity to heat a 12-car train.

The 180-ton locomotive was selected for service on the New York, New Haven and Hartford Railroad as the best size of unit to meet all of the operating requirements. It is desired to handle all of the heavy passenger trains with a single engine, and the 180-ton locomotive has the capacity for this work. The heaviest of the express trains consist of 12 Pullman cars of 75 tons each and 900 tons trailing load. The 180-ton locomotive is capable of hauling a train of this weight between Grand Central Station and New Haven in 99 minutes on a non-stop run. This is a schedule speed of over 44 m.p.h., a remarkable performance when the numerous necessary slow-downs are considered. With stops at 125th Street, Stamford, South Norvalk, and Bridgeport, the run can be made with the same weight of train between Grand Central Station and New Haven in 115 minutes, provided the aggregate of the stop time does not exceed 7 minutes. In local service, trains of 460 tons trailing load can be handled.

The new locomotives also operate over the New York Connecting Railroad and Hell Gate Bridge into Pennsylvania Station. They are capable of hauling a 900-ton train from New Haven to Pennsylvania Station in 110 minutes on a non-stop run. On one section of the west-bound Hell Gate Bridge approach, the grade averages 1.16 per cent. for two miles, with a maximum of 1.22 per cent. The heaviest demand is placed on an engine when it is ascending the west-bound approach on this bridge.



Oil-Fired Flash Boiler for Train Heating

Twelve new locomotives are being purchased at the present time, as this number is required to provide 100 per cent. electric passenger service. There has not been sufficient electric motive power to accommodate all of the passenger trains, and a number of them have been operated with steam engines, particularly those routed over Hell Gate Bridge. Operating officials desire to handle all of the passenger trains with electric power to secure more efficient and reliable service, as well as to keep the steam equipment out of the electric zone. After the twelve new locomotives are placed in service, all passenger trains will be hauled by electric engines, both on the main line and on the New York Connecting Railroad.

The five 180-ton passenger locomotives that have been in service the past four years are operating successfully. They have proved their ability to perform the service satisfactorily, and have an excellent record. The engines frequently make over 500 miles per day, which is a very good performance when it is considered that the longest single trip that is made is 72 miles, the distance from New York to New Haven. The record of these engines is very pleasing, and substantiates the belief that this type will meet the demands of passenger traffic on the railroad for many years to come.

Another interesting fact is the record of the 41 original Westinghouse passenger locomotives of the 2-8-2 gearless type (0-1 to 0-41). A number of these engines have now made over 1,000,000 locomotive miles, and the others are very close to this figure. This is the result of sixteen years of successful operation, and is a very remarkable record.

THE LOCK-NUT PROBLEM

British engineers with a sarcastic turn of mind have been heard to say that samples of every device for locking nuts tightly upon bolts can be found lying at the stopping places of London omnibuses. This is an exaggerated way of expressing the fact that many of the so-called infallible lock-nuts fail under very strenuous conditions. On the other hand, it should not imply that all lock-nuts are unsatisfactory under ordinary conditions. There is, however, still room for invention in connection with lock-nuts for resisting extra heavy vibration. A British engineer offers a new solution which has been proved exceptionally satisfactory under very trying conditions. The device consists of two nuts, a lower one with a split cone at its upper end, and an upper nut with a corresponding conical recess. When the upper nut is screwed home, it tightens up the split cone firmly on to the bolt, and unlocking is prevented by a small pawl let into the recess in the upper nut. This pawl allows the two cones to move freely over each other during screwing up, but it locks them together so that any slacking back is effectively prevented. At the same time the two nuts can be easily unscrewed when required. Lock-nuts of this type have remained tight after a fortnight's continuous service on a hammer forging gun barrels. The nuts previously used on this mechanism required tightening every twenty minutes, and had to be replaced every four or five hours.

We are informed by the Selby Engineering Co. Ltd., 92 Fenchurch Street, E.C., that they are prepared to execute orders from British India (retail or in bulk) for Navaline Lac-paint. This quick-drying enamel is used extensively by steamship and railway companies, factories, etc., and its non-cracking, sun-resisting properties render it valuable for use under trying conditions. It is supplied in white, black, and a large variety of colours, while any shade can be matched to order.

Some Recent Developments of Powdered Coal Firing

(Continued from page 586.)

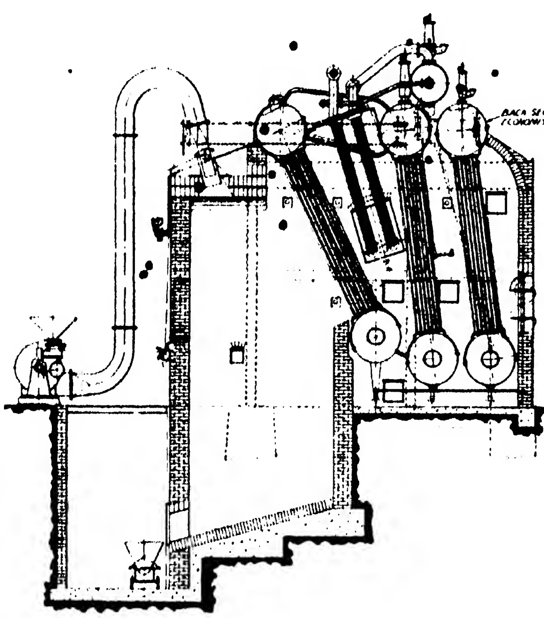


Fig. 3. Turbo-Pulveriser Firing a Woodeson Boiler

cent. should not be maintained over a lengthy period, and not just during an acceptance test. With metallurgical furnaces, such as forge, heating, reheating, annealing or evaporating pots or tanks, high efficiencies can be

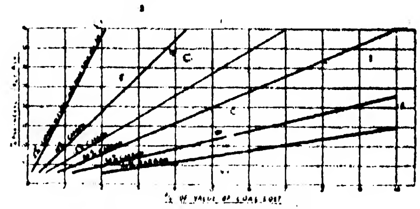


Fig. 5. Loss in Heating Value of Coal with Different Percentages of Unconsumed Carbon in Ash

maintained. In addition to the advantages enumerated, there is always the ability to use cheaper grades of fuel, owing to the fact that small, dusty coals answer the purpose very well and are always obtainable at a low price.—(*To be continued.*)

the rapid combustion, the gases leaving a boiler fired with powdered coal are usually lower in temperature than the gases from a boiler working at the same rating and fired either by means of a mechanical stoker or by hand. It is quite possible to maintain the CO_2 readings of 16 per cent. and over. The table at foot of page 586 shows the readings taken on one of a number of tests made by independent chemists.

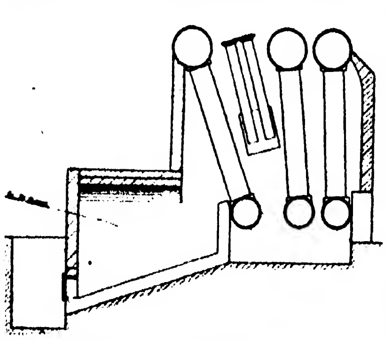


Fig. 4. Incorrect design of Combustion Chamber for Burning Pulverised Coal

There is another great saving to be obtained with powdered coal firing and this refers more particularly to the ash. It is often found that from 12 per cent. to 14 per cent. and in some cases -which are by no means so rare as one would think—up to 40 per cent. of unconsumed carbon is taken away with the ashes from below a hand-fired or mechanically-fired boiler grate. Fig. 5 shows the loss in the heating value of the coal, with different true ash percentages in the coal and with varying percentages of unconsumed carbon in the ash taken away from the ashpit. This curve is perhaps somewhat elementary —but the author does not remember the figures being shown in this way before.

With regard to flexibility, the taking of peak loads and the elimination of banking and damping, a powdered-fuel plant, suitably designed, is just as convenient as gas or oil. Starting up after a week-end or a night stoppage, either in connection with a boiler or a metallurgical furnace, can be carried out much more quickly. In practice, this of course means a very material saving in coal burnt over a lengthy period. With a suitably-designed powdered-coal-fired boiler, together with superheater and economiser, there appears no reason why an overall efficiency of 80 per

INDUSTRIAL HEATING CONGRESS IN PARIS

There will be held in Paris, from June 10th to 16th, an important Congress on Industrial Heating, together with an Exhibition from June 1st to 17th, of the apparatus, drawings, etc., under discussion, the whole being under the direction of the Conservatoire National des Arts et Metiers. The office of the Congress is the Ministry of Public Works, 246 Boulevard St. Germain, the Hon. President being the famous French scientist, M. Le Chatelier, and the President M. Walckenaer, the Chief Inspector of Mines of the French Government. We understand that the work of the Congress, to which representative engineers from different parts of the world, including Great Britain, have been invited, will cover a very wide field, including the methods of analysis of fuels, the causes of the fusibility of ash and clinker, steam boilers and furnaces of every description, scientific apparatus for the study and control of efficient combustion (particularly pyrometers and apparatus for the automatic analysis of gases), pulverised fuel, boiler plant testing, oil firing, etc., etc.

INDUSTRIAL INDIA

EDITOR
J. R. SARJANTSON

LONDON OFFICE
KERN HOUSE
KINGSWAY, W.C. 2

ASSOCIATE EDITOR
J. D. TROUP, M.I.Mech E

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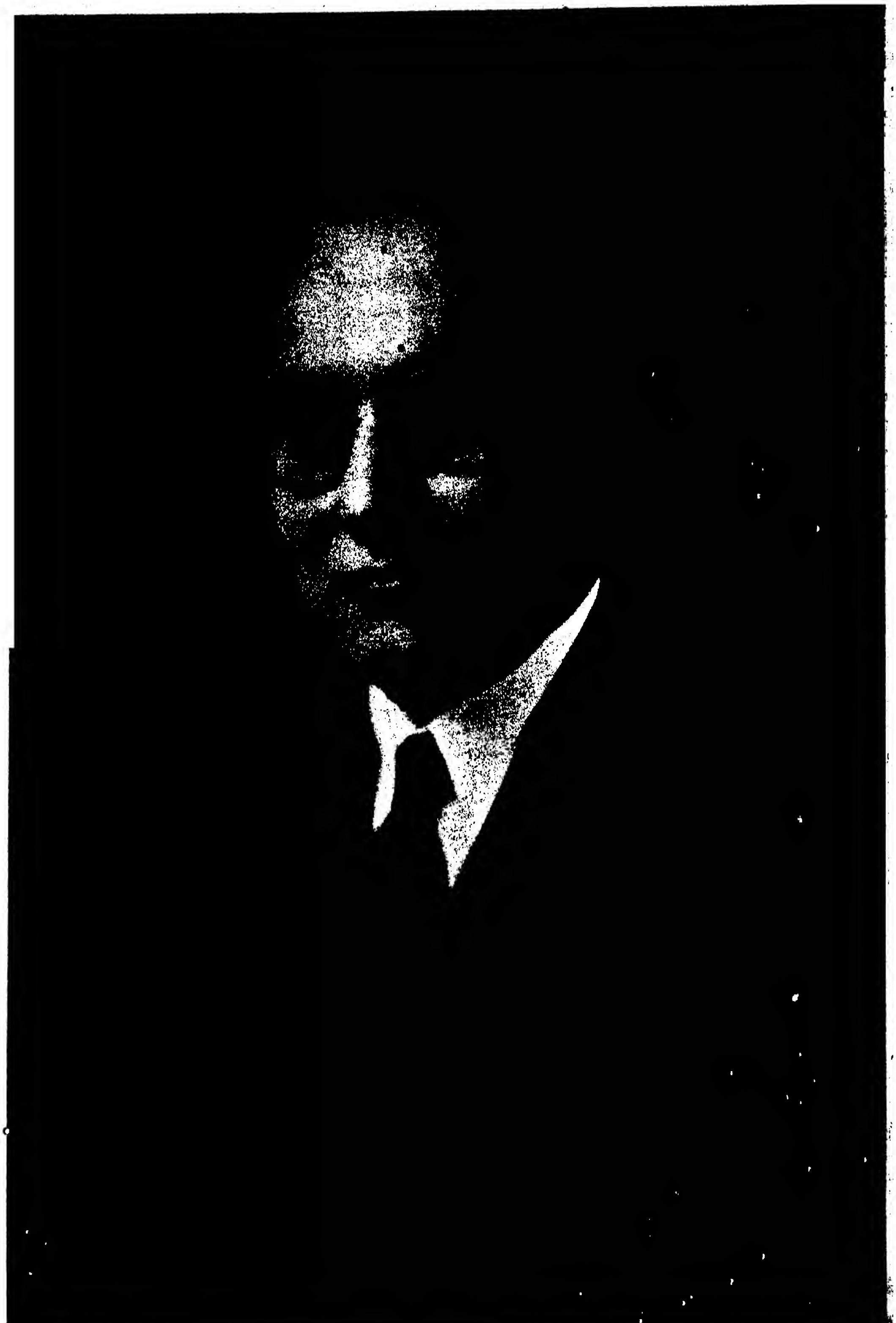


DR. B. D. SAKLATWALLA,
An Eminent Indian Engineer

INDUSTRIAL INDIA

A MONTHLY REVIEW DEVOTED TO THE DEVELOPMENT OF INDIA'S RESOURCES AND INDUSTRIES

Volume II | JULY, 1923 | Number 12

BETWEEN OURSELVES

DR. B. D. SAKLATWALLA—whose portrait forms the frontispiece to this, the concluding number of the second volume of INDUSTRIAL INDIA—is an eminent Indian engineer and metallurgist, and at present holds the position of General Superintendent of the Vanadium Corporation of America, and member of the board of directors of the Vanadium Corporation of America, and also of the American Vanadium Company. Dr. Saklatwalla was born in Bombay on July 19th, 1881. He was educated at St. Xavier's High School and College, and matriculated in 1897, graduating in 1901 with the degree of Bachelor of Science from the University of Bombay. He was awarded the J. N. Tata Educational Scholarship. He proceeded to Germany and joined the Royal Polytechnicum at Charlottenburg and the Mining Academy and University of Berlin. In 1906 he graduated from the Royal Polytechnicum, obtaining the engineering diploma in metallurgy. In 1907 he was elected Andrew Carnegie Research scholar by the Iron and Steel Institute of London, England, for carrying on research in the metallurgy of steel, and in 1908 he was awarded the post-graduate degree of Doctor of Engineering by the Royal Polytechnicum at Charlottenburg in the faculty of metallurgical engineering.

In Germany, Dr. Saklatwalla acquired considerable practical experience in the works of Ludwig Loewe und Sohn, of Berlin, and the Maschinenbauanstalt Humboldt, of Cologne, also developing new processes for the production of tungsten filaments for lamps, which were patented. He, moreover, contributed several papers of technical interest and value to the journals of technical societies both in Germany and England.

In 1908, Dr. Saklatwalla left Germany for the United States of America, and in 1909 he entered the services of the American Vanadium Company as process chemist, then metallurgist, and General Superintendent in charge of all operations. He developed, from 1909, the metallurgical processes for the reduction of vanadium so as to make the extraction and use of this rare element commercially possible. He developed and patented processes and improvements in treating vanadium ores, smelting ferro-alloys, electric furnace treatment of ores, electrical devices for regulating and controlling electric furnaces, and producing alloy steels and iron. And once again he contributed valuable papers which he read before the American Chemical Society and the American Electrochemical Society, and these were published in the journals of the two societies and other technical periodicals. Dr. Saklatwalla is a member of the Chamber of Commerce of Pittsburgh, Pennsylvania, a Fellow of the Royal Society of Arts, England, and a member of the following scientific and technical societies: American Chemical Society, American Electro-Chemical Society, American Society for Advancement of Science, American Society for Testing Materials, American Society of Steel Treaters, American Institute of Mining and Metallurgical Engineers, The Iron and Steel Institute, London, and The Institute of Metals, England. A career more closely packed with useful and distinctive work it would be difficult to imagine. Dr. Saklatwalla has "made good" in the three greatest industrial countries of the world, and his success should inspire and encourage every young Indian who has taken up, or hopes to take up, engineering as a profession.

* * *

Structure of Alloys

The thirteenth annual May Lecture of the Institute of Metals was delivered on Wednesday, May 2, at Storey's Gate, Westminster, by Dr. W. Rosenhain, F.R.S., of The National Physical Laboratory.

Referring to the great accumulation of facts in regard to the properties and microstructure of alloys which have been forthcoming in recent years, the lecturer said that the time had arrived when it was most desirable that there should be found a key to this maze of knowledge in the form of a general theory that would link together the mass of facts into a homogeneous whole. Such a theory he attempted to put forward, basing it upon the intimate knowledge of crystal structure which had recently been acquired by means of the application of X-rays to the study of the arrangement of atoms in crystals. The crystal structures found in pure metals became modified in the case

of alloys, particularly in those called solid solutions, where a second kind of atom, the atom of the alloying element, entered into the structure of the crystal and produced in it certain minute changes. With regard to such changes, the lecturer put forward two simple principles and was then able to show a striking series of inferences from his theory, which accorded closely with a large number of experimental facts. Connections between various series of properties in metals and their alloys were established which had not formerly been recognised, such as the relation between hardness and alloying power. Especially important is the connection between the minute distortion of crystal structure which occurs in alloys, and their behaviour on melting and freezing, while such phenomena as plasticity, diffusion, and others fell easily into line with the same type of explanation. Most important of all, perhaps, is the fact that this new theory of alloy structure affords a ready explanation of the electrical properties of metals and alloys, and the changes of those properties when the metal is heated or cooled. The explanations cover the mysterious phenomena of superconductivity found in many metals when cooled nearly to the absolute zero of temperature.

* * *

Listening to Dirt

It is not only in picturesque colloquial language that dirt can be described as making itself heard. In actual scientific experiments recently carried out in Great Britain, the presence of dirt has made itself audible. This remarkable phenomenon arises from the use of the "thermionic valve," which is now the essential thing in wireless telephony and "broadcasting." The application mentioned is in connection with the cleaning of photographic prints. The apparatus used for washing is much the same as usual, but it is connected to electrical appliances in such a way that when dirt remains in the developing dish the balance of two electrical currents is upset. This lack of balance causes a very minute current to flow, and this minute current is magnified by three valves so as to make an audible sound through a telephone. As soon as the bath is free from dirt the electrical balance is restored, and no sound is heard. In this way the photographer gets an absolute accurate and ready means of ascertaining when the lengthy process of print washing is completed. The thermionic valve, it is interesting to note, is the invention of an English man of science, and was the instrument above all which enabled the British Navy to combat the submarine menace.

* * *

"Spit and Polish"

This not very elegant phrase was the standard method in the British Army of referring to the tedious business of keeping oneself spick and span in spite of Flanders mud and any other form of material in the wrong place. Every member of H.M. Forces probably considers himself an expert on polish, and quite capable of delivering a long and highly eloquent lecture on the subject. Nevertheless, from the scientific point of view, it is a fact that this laborious and very ancient business of polishing has never, until lately, been properly studied. Every now and again some remarkably new polish makes its appearance—and its disappearance; and people are apt to jog along with various materials to which they have become accustomed. A British Metal Research Association has, however, undertaken a thorough research into the materials and methods used in polishing every variety of metal article. The allied subject of grinding has also been investigated, and the experts engaged on the work found that definite information about what actually happened in grinding and polishing was completely lacking. Very interesting work has already been done in collecting information and making experimental tests; and results of the highest importance are expected to accrue from this British enterprise.

A Giant Telescope for Russia

In view of the condition of Russia as represented by the usual accounts of famine and disorganisation, it is rather surprising to find that the Government of that country has ordered a telescope which is one of the largest in the world. This telescope has just been completed in a British factory, and will shortly be transported to an observatory on the shores of the Black Sea. It weighs about nine tons, and the inside length of the tube is 45 feet. Heavy as the telescope is, it is so admirably fitted that it can be moved by electrical means as easily as if it were a small portable apparatus. The push-button system of control has been adopted, so that all the operator has to do to direct the telescope to any part of the heavens is to press certain buttons. A second telescope almost as large as this is being made at the same British factory for another observatory in Russia. So delicate is the work on these giant instruments, that about three years are occupied in designing and constructing them.

"Under Hatches"

This familiar old nautical phrase will convey unpleasant memories to passengers who are fond of good weather at sea. To the ship designer they convey a sense of a mechanical problem not, until recently, satisfactorily solved. Strange as it may seem, there has been an unsatisfied need for a really simple and effective method of locking the hatches on a cargo vessel. A British engineer has lately introduced a device which claims to meet every requirement, and to be applicable to any size or form of cargo hatch. Moreover, it can be fitted to existing hatches with very little trouble. Across the centre of the hatch is placed a T-shaped bar which holds down the wood covers of the hatch and is itself held by a self-acting slip bolt. The act of dropping the bar in place locks the hatch, which can be reopened only by means of a special key. Further safety can be ensured by the use of a lever lock. All the vital parts of the equipment are inaccessible, so that they are not liable to damage.

Thornycroft Lorry Succeeds in French Tests

Information is to hand regarding a series of official trials for wood and charcoal gas-consuming motor lorries, conducted by the French Automobile Club, and the Offices des Recherches et Inventions. There were five competitors, and the only British entry—a Thornycroft vehicle—was classed an easy first. The tests were of two kinds—bench and road, the latter comprising the running at an average speed of 15 km. 600 per hour, over a distance of 60 kilometres. The bench tests lasted in each case 10½ hours.

INDUSTRIES

Conducted by FRANK DAWSON

THIS MONTH WE ARE FEATURING A SERIES OF SPECIAL ARTICLES RELATING TO THE MANUFACTURE OF TEA AND THE TURPENTINE INDUSTRY

The Manufacture of Tea

How the British engineer invented, manufactured and supplied the machinery which has made the Indian tea industry supreme

WHEN the housewife buys a packet of her favourite brand of tea, she expects it to possess the same identical qualities as the packet which she bought the week before, and every process in its preparation is carried out with such care and precision that this condition is practically guaranteed. And this is all the more remarkable when it is remembered to what huge proportions the tea industry has grown. In India in 1921 the total area under tea was reported to be 691,800 acres, and the total production of manufactured tea was reported to be 377,055,600 lb. How the British planter in India, Ceylon, Burma, and the Shan States swiftly won a supremacy over the China and Japan tea trade is a matter of history. How the British engineer rose to the occasion, and invented, manufactured, and supplied the machinery which has contributed to and ensured that supremacy is perhaps not so well known; or so generally realised, but we hope in this series of articles to pay tribute to this enterprise, and to clearly describe some of the most interesting machinery and mechanical devices employed on the tea estates and in the tea factories of India.

One of the pioneer British firms in this particular direction was Messrs. Davidson & Co. Ltd., of Belfast, and we will start by giving the story of their achievement.

Tea as a Beverage

Tea has been recognised as a beverage in the Western Countries of the World for the past three centuries, but its consumption during the greater part of this period was comparatively small, due to its being exclusively of Chinese origin and exported only in small quantities. With the commencement of the 19th Century the cultivation of the tea plant was considerably developed in India, and later on in Ceylon and Java, with the result that these three countries have now virtually ousted the Chinese product from the European markets, with the exception of Russia. It may be interesting to mention that tea has also been successfully cultivated in Sumatra, Natal, British East Africa, French Indo-China, and the Caucasus of Russia, for all of which districts there has been a demand for Messrs. Davidson's machinery and factory equipments. Experimental plantations were also started in Virginia by the U.S. Agricultural Department, but these do not appear to have been successful, as the machinery was offered for sale some few years ago.

The progress of the development in tea manufacture has been particularly rapid during the last 50 or 60 years, and has been chiefly brought about by the application of science to the cultivation of the indigenous plant and to the methods of manufacture. The application of scientific principles has practically doubled the yield of leaf per acre, while the introduction of machinery for the process of manufacture has enabled the planter to cope with this increased output of his garden without difficulty and without the employment of a proportionate increase of labour.

It would seem that, because the tea leaf was of Chinese origin, the primitive methods of manufacture of that country were slavishly copied in the early days, and these methods, cumbersome in the extreme and lacking entirely in hygienic qualities, continued to be employed for many years. But it was only natural that when this new industry began to engage seriously the attention of European planters that Western science should gradually be introduced into the manufacturing process of the leaf, and that machinery should by degrees take the place of the primitive hand methods. One of the foremost pioneers in the application of science to the manufacturing end of the industry was Mr. S. C. Davidson, who at that time was a practical tea planter. Mr. Davidson recognised early in his career as planter that if the success of the tea industry was to be assured it was absolutely essential that machines should be utilised in order to increase the production of a garden. Being of an inventive turn of mind he immediately set about devising some method of drying the leaf on a larger scale than was possible with the "Chulas," using charcoal fires, which were in general use at that time. The outcome of his experiments was a drier called the No. 1 Sirocco, which was very successful, and was the forerunner of many other and larger driers that have been evolved by this inventor. Contemporaneously with the development of mechanical driers, machines were gradually introduced into the other processes of manufacture of the leaf, and such progress has been made in this respect that little remains at the present day of the methods in general use during the early part of last century.

In this article we give a brief description of the various "Sirocco" tea machines, which are now so well known in every tea-growing country of the world.

Fig. 1. View of Indian Tea Garden, with Factory in distance

Withering

Machinery plays an important role in the very first process through which the freshly-plucked leaf passes on its arrival at the factory, and that is in the withering lofts. The leaf, having been weighed, is spread thinly on shallow trays and allowed to remain there until it has become quite soft and flaccid, a process which under natural conditions usually occupies from 18 to 20 hours. The great disadvantage of natural withering is the influence that the change in climatic conditions has upon the conditions of the leaf. At night the atmosphere may be cold and moisture laden, and consequently the wither, when carried out under such conditions, is greatly prolonged, owing to the leaf reviving to a certain extent, causing thereby serious delay to all the work in the factory.

By the use of fans, properly proportioned and correctly applied, the entire volume of air in the lofts can be positively and evenly controlled, thereby enabling the temperature and saturation to be regulated, and ensuring results equal to those obtained under the most favourable natural conditions. Uniformity and regularity of wither can be obtained on account of the entire air contents of the loft being under control, the flow of air over the leaf being the same at all parts. Further, the capacity of the lofts is increased, as a good limp wither can be secured by the aid of fans in six to ten hours, which is considerably less than under natural conditions.

The fans usually employed for this purpose are of two types, namely, centrifugal cased fans and wall fans, the first being placed on the floor of the loft, while the second are arranged for building into a wall. In the warmer tea districts the withering house is frequently a separate building, but in the cooler districts the process is often carried out on the upper floors of the factory itself, and the hot exhaust air emanating from the driers on the ground floor is utilised to assist the withering process. The two types of fans illustrated are the most satisfactory, because they have a large volumetric capacity at slow speeds and are positive in action under all conditions of weather. Propeller fans are not suitable, as they are often rendered inoperative by opposing wind pressure.

Rolling

The withering being completed, the next step is the rolling of the leaf. In the early days this used to be performed by the coolies by the aid of their hands and feet, a somewhat tedious and certainly unhygienic method. This primitive way has entirely been superseded by rolling machines which very successfully reproduce the hand method and give the leaf not only its characteristic twist, but also rupture the leaf cells. This produces an exudation of the juices in order that they may oxidise when they come into contact with the air.

Fig. 2. Weighing freshly plucked leaf

Fig. 3. "Sirocco" Cased Fans for erection on the floor of a withering loft

Fermentation

Fermentation being a chemical action, no machinery is required during this stage, but a roll breaker is usually employed to break up, cool, and roughly sort the leaf coming from the rollers and prior to fermentation.

Drying

Since the introduction of mechanical driers, as exemplified in the No. 1 "Sirocco" referred to earlier in this article, considerable strides have been made in this type of tea machine, both as regards its capacity and its mechanical design.

The No. 1 "Sirocco" was termed an up-draft drier, and was self-acting, that is to say, the drying chamber, containing a number of trays for holding the leaf, was placed immediately above the direct-fired air heater, the hot air from the latter passing by convection upwards through the drying chamber and through the trays of leaf contained therein. The first drier of this type had only four trays, and its capacity was consequently small, but larger machines with more trays of greater superficial area were gradually evolved and became very popular among the planters. It will be observed that these up-draft driers do not require mechanical power for their operation, a necessity in those early days of the tea industry, when the existence of an engine in the factory was the exception and not the rule. While the up-draft driers have in the majority of gardens been now replaced by larger and more modern driers, they are still being used in quite a considerable number for the purpose of the final firing of the tea.

Fig. 6. "Sirocco" Roll Breaker

The next development in tea drying machinery is represented by the down draft "Sirocco" tea drier, in which mechanical power was required for the operation of the fan that draws the heated air from the stove into the drying chamber. By the aid of the fan a larger volume of hot air could be passed through the trays of leaf, with the result that the capacity of these driers was, generally speaking, larger than that of the up-drafts. They are like the up-draft machines, still being used with great success for final firing, and are much in request for this purpose.

It is interesting to observe the improvements carried out in each successive type of drier. In the up-draft machines the movement of the trays from the top of the drying chamber to the bottom had to be performed by hand, in the down draft driers the upward movement of the trays was accomplished mechanically by means of a lever, in both cases, however, the drying being finished at the highest temperature. The movement of the leaf through the drying chamber has been still further improved until it has become first, semi-automatic, and finally, entirely automatic. The "Sirocco" enclosed type tilting tray pressure drier may be termed a semi-automatic type of drier. It is fitted with trays having a tilting movement, whereby the leaf is transferred from one line of trays to the next lower, and the finished tea finally discharged from the bottom line of trays into a collecting chamber in the base of the drier. The top line of trays slides out of the drying chamber, so that the attendant can spread the leaf upon it without being exposed to the hot blast of exhaust air. Having pushed back this first line of feed drawer, the attendant then turns a crank handle, which tilts successively the four lines of trays below the feed drawer, commencing with the lowest, and thus leaving the top row empty. By releasing a control lever on the feed drawer, the trays of the latter are tilted and the leaf dropped on the row below. On returning the lever to its original position, the trays are brought back to the horizontal, and the drawer can be pulled out for recharging. The same principle of finishing off the drying at the highest temperature is followed also in this machine, but by means of a by-pass a small proportion of hot air is introduced below the top row of trays in order to check rapidly the fermentation of the leaf. This drier, which is slightly larger in capacity than any of the earlier drying machines, is particularly suitable for gardens, the output of which is not sufficiently large to warrant the installation of an auto-

Fig. 4. "Sirocco" Wall Fan, exterior view

Fig. 7. Old method of Drying over Charcoal Fires (Chulas)

Fig. 5. Old (Chinese) Method of Rolling Tea Leaf

matic drier which is described in the next paragraphs.

The "Sirocco" endless chain pressure drier is not only one of the most modern, but also one of the largest tea driers. It is entirely automatic in operation, and together with the automatic feeder and spreader, which has been added within the last eighteen months, represents the most up-to-date and complete tea drier now on the market.

The coolies empty the wet leaf into the feed hopper of the feeder and spreader, the hopper being arranged at a convenient height from the floor for this purpose. The leaf in travelling upwards upon the endless band of trays encounters a rotating spreading plate, which combs out the wet leaf, breaks up any balls, and allows the leaf to pass on, spread like a carpet in a perfectly even, loose, and regular condition. The spreading plate can be easily adjusted while the machine is in operation to give any desired depth of spread, which is kept quite uniform over the entire surface of the trays. On reaching the upper end of the automatic spreader the leaf falls lightly on to the top row of trays of the drying chamber. Prior to the introduction of this automatic feeder and spreader, the feeding had to be performed by hand, but with the introduction of this new adjunct not only is a considerable amount of labour saved, but the capacity of the drier itself is thereby increased and a more uniform and regular drying of the tea secured.

Drying Chamber

The drying chamber of the endless chain pressure drier is fitted with three endless bands of trays, which travel from one end of the machine to the other, forming six drying surfaces. When the leaf has been discharged by the spreader upon the top row of trays, it is carried to the far end of the chamber, where it is dropped upon the next row of trays moving in the opposite direction. The leaf thus travels backwards and forwards in the drying chamber six times, emerging at the bottom of the chamber immediately below the spreader. The principle of drying is again the same as in the other driers, the drying of the leaf being finished at the highest temperature, the hot air being discharged by a fan into the bottom of the drying chamber and passing upwards through the six rows of trays. To check the fermentation of the leaf as soon as it enters the drying chamber, a by-pass is fitted, conveying a portion of the hot air from the bottom of the chamber to the underside of the top and second rows of trays.

The heater used with this machine is of the well-known "Sirocco"

Fig. 8. A 16 Tray Up-Draft "Sirocco"

Fig. 9. No. 1. Up-Draft "Sirocco"

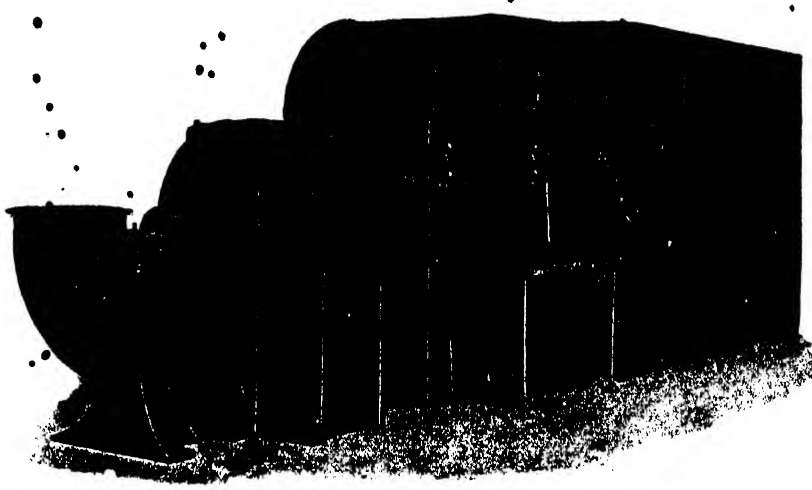


Fig. 10. "Sirocco" Down Draft Tea Drier

All the illustrations used in this article are reproduced by the courtesy of Messrs. Davidson & Co. Ltd., Sirocco Engineering Works, Belfast.

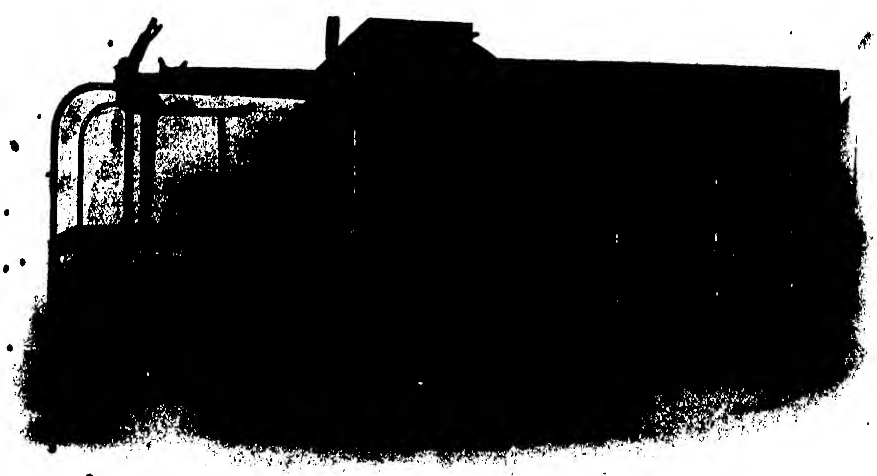


Fig. 11. "Sirocco" Enclosed Type Tilting Tray Pressure Drier

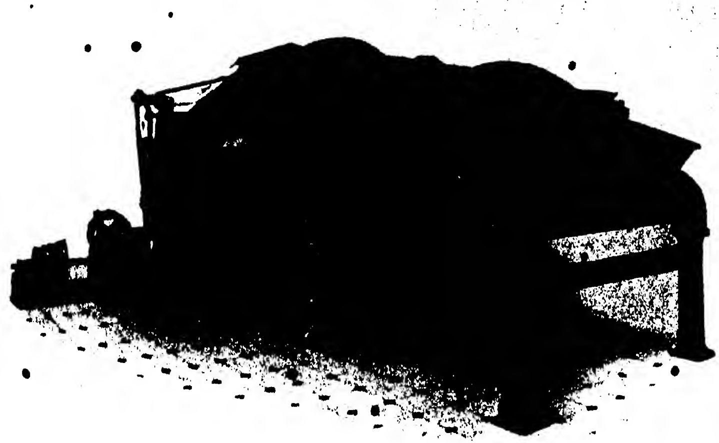


Fig. 12. "Sirocco" Endless Pressure Drier. View of Drying Chamber and Automatic Feeder and Spreader

multitubular type, and is fitted with a centrifugal fan, which draws the hot air from the heater and propels it into the base of the drying chamber. The heater will burn coal, coke, or wood, or it can be fitted with a suitable equipment for burning oil fuel. When using coal it can also be fitted with a mechanical stoker.

From the above description it will be seen that in the "Sirocco" endless chain pressure drier, which is made in two sizes, the amount of labour required has been reduced to a minimum, its operation being almost entirely automatic.

In the accompanying table we give particulars of some tests carried out with two sizes of endless chain pressure driers on different estates in India and Ceylon. In every case, of course, tea is the material being dried, but it must be borne in mind that the condition, *i.e.*, the moisture contents, of the wet leaf entering the drier varies according to the extent of the wither which the leaf has undergone prior to the drying process. The method of drying is not the same on every estate; on some it is the rule to dry the leaf only partially in the endless chain pressure driers and finish it off later in smaller driers, while on other estates the tea is completely dried in the large drier. This difference of procedure has naturally a decided influence upon amount of evaporation per pound of fuel, as it stands to reason that to extract the final 25 per cent. of moisture from the leaf takes comparatively more fuel than in the earlier stages of the drying process. In this connection it may be of interest to give the terms used for designating degrees of dryness in vogue in India. The currency of the country is employed for this purpose. There are sixteen annas in a rupee, consequently the planter speaks of "12 anna" dried tea to convey that it is 75 per cent. dry.

In the sixteen tests it will be observed that three classes of fuel were used, namely, coal, wood, and oil. The calorific value of Assam coal is in the neighbourhood of 10,000 B.T.U. while that of wood and oil may be taken as about 5,000 B.T.U. and 20,000 B.T.U. respectively. In tests 1, 2 and 4 of the large drier, and in test 1 of the small drier, the multitubular air heaters were equipped with mechanical stokers.

Sorting

The tea coming from the driers is then sorted into different grades, of which there are usually five. This is performed by a machine consisting of a rotating cylinder fitted with brass mesh. The brass mesh is of five different sizes to suit the same number of grades of tea. Prior to the leaf entering the sorting drum it passes through a cutting mill which forms

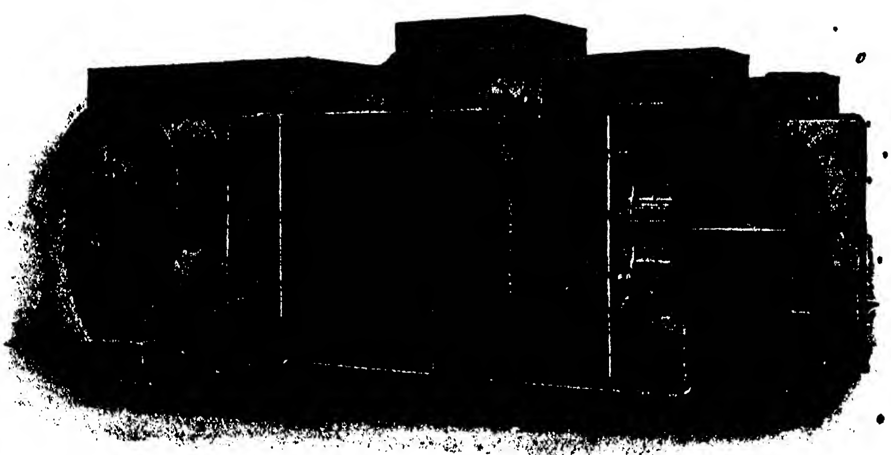


Fig. 13. "Sirocco" Endless Chain Pressure Drier. View Showing Heater and Drying Chamber, but without Automatic Feeder and Spreader

Fig. 14. Mechanical Stoker fitted to an Air Heater of a "Sirocco" Tea Drier

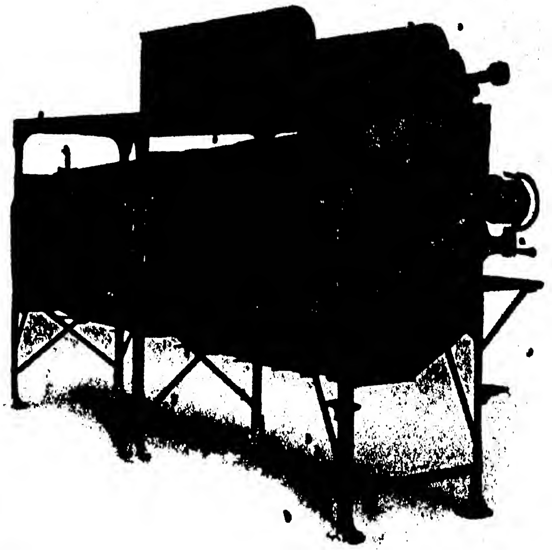


Fig. 15. "Sirocco" Tea Cutter and Sorter

part of the machine and breaks up the coarse tea preparatory to sorting.

Final Firing

Previous to packing the tea it is the usual practice to subject it to a final firing in order to dry it thoroughly and to evaporate any moisture it may have absorbed while waiting to be packed. The machines used for this purpose are generally of the up-draft or down-draft type, as described in the section relating to the drying process.

Packing

As soon as the tea comes from the driers in which it has been finally fired, it is packed immediately into chests. Here again a mechanical contrivance is employed in place of the earlier practice of hand packing. The Packer consists of a rocking table upon which one or two chests are clamped, and which are subjected to a rapid vibratory movement. By the use of these machines it is possible

Tests of Endless Chain Pressure Driers

LARGE MACHINE.

Test No.	Country.	Class of Fuel.	Amount of damp material per hour.	Amount of dry material per hour.	Moisture evaporated per hour.	Fuel consumed.	Lbs. of moisture evaporated per lb. of fuel.	Lbs. of dry material per lb. of fuel.	Percentage of dryness of dried material.	Remarks.
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		
1	India	Assam Coal ...	1075	373	702	160	4.4	2.5	92%	Dry Bulb, 90° —
2	India	Assam Coal ...	1247	672	577	137	4.2	4.9	65%	" " 90° —
3	India	Assam Coal ...	1744	587	1157	220	5.2	2.7	86%	" " 104° —
4	India	Assam Coal ...	1002	379	623	153	4	2.5	82%	" " 100° —
5	India	Bengal Coal ...	1330	595	735	167	4.4	3.6	83%	" " 120° —
6	Ceylon	Jungle Wood, good	1013.6	400.24	613.36	432	1.41	.92	100%	" " 83° Wet Bulb 75°
7	Ceylon	Jungle Wood, good	949	409.5	539.5	359.5	1.5	1.14	100%	" " 95° " " 83°
8	Ceylon	Oil Fuel ...	1231	531.5	699.5	108	6.37	4.92	100%	" " 88° " " 76°

SMALL MACHINE.

Test No.	Country.	Class of Fuel.	Amount of damp material per hour.	Amount of dry material per hour.	Moisture evaporated per hour.	Fuel consumed.	Lbs. of moisture evaporated per lb. of fuel.	Lbs. of dry material per lb. of fuel.	Percentage of dryness of dried material.	Remarks.
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		
1	India	Assam Coal ...	817	436	380	81	4.7	5.3	76%	Dry Bulb, 100° —
2	India	Assam Coal ...	762	253	509	120	4.2	2	88%	" " 116° —
3	India	Assam Coal ...	986	426	559	106	5	4	86%	" " 84° —
4	Ceylon	Jungle Wood, good	742	290	452	226	2	1.28	100%	" " 84° Wet Bulb 73°
5	Ceylon	Jungle Wood, green	633	258	375	402	.93	.64	100%	" " 84° " " 73°
6	Ceylon	Jungle Wood, good	651.2	248.6	402.6	398.6	1.01	.62	100%	" " 85°
7	Ceylon	Oil Fuel	800	350	450	81	5.55	4.32	100%	" " 80° " " 74°
8	Ceylon	Oil Fuel	644.83	308.33	336.5	54	6.23	5.7	100%	" " 82° " " 78°

Fig. 16. "Sirocco" Tea Packer

to pack about 5 to 8 per cent. more tea into the chest than can be done by hand, while saving at the same time a considerable amount of time and labour. Further, machine packed tea not being subjected to pressure, is not damaged or broken when handled by these machines.

Messrs. Alfred Herbert (India) Ltd. have taken over the agency for the following British manufacturers:—

Electromotors Ltd., Openshaw, Manchester, for their complete range of dynamos and motors for D.C. and A.C.

Igranic Electric Co. Ltd., Bedford, for starting and controlling devices.

Berry's Electric Ltd., London, for Ironclad switches and fuses.

The Engineering Lighting Equipment Co. Ltd., St. Albans, for commercial lighting fittings.

Indian Forest Industries—Turpentine

By T. K. MIRCHANDANI, B.E. (Civil), P.F.S.
Extra Assistant Conservator of Forests and Instructor F.R.I., and College, Dehra Dun

IT may probably interest some of the lay readers of this magazine to know that a great bulk of the turpentine oil used in India is produced and manufactured in India. It is a Swadeshi industry, worked and controlled by the Government, and is very profitable.

The turpentine oil is the chief distillation product from the distillation of oleo resins exuded from certain conifers known under the common name of Pines. In India the chief species which at present yields this resin in sufficiently large quantities, and at a reasonable cost of extraction, to work it successfully on a commercial scale, is Pinus longifolia, commonly known as Chir Pine. This species occurs in abundance in the U.P. and the Punjab Himalayas from the elevation of about 1,500 feet to 5,500 feet.

Resin Collection

There are usually two methods adopted for tapping the trees in India: (1) light and continuous tapping; (2) heavy or dead tapping.

The last method is adopted only in case of trees marked for felling. The object is to collect as much resin out of the tree before felling as practicable. The tree is blazed on all sides, and galvanized iron lips inserted (as far deep as the first two to three years' sap wood) (refer to Fig. 2), to lead off the resin into the receiving basin hung below the cut.

The second method is based on the general principle of sustained annual yield. Under this method usually trees over 3 ft. in girth are considered mature and ready for tapping. One blaze per year is made in a tree between 3 ft. to 4 ft. 6 in. in girth, two in a tree up to 6 ft. in girth, and three in over 6 ft. girth.

The first blaze is made 6 in. above the base of the tree, and is 6 in. × 4 in. × ½ in. at the very start. The second year's blaze is made over the blaze of the first year, and so on for five years. (Fig. 1.) In the sixth year the blaze will again be near the base of the tree, only a few inches away from the blaze of the first year. It thus requires about thirty years to go round a tree of 3 ft. girth, and by that time the first year's wound has healed up. This allows of the continuous annual tapping of the same trees, provided there be no external danger increased by this method.

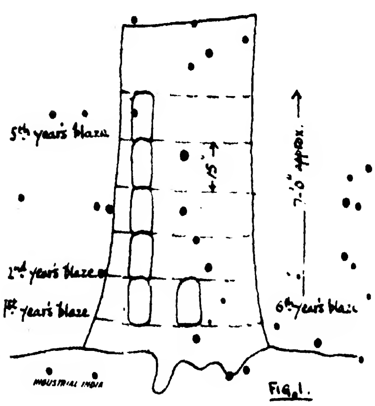
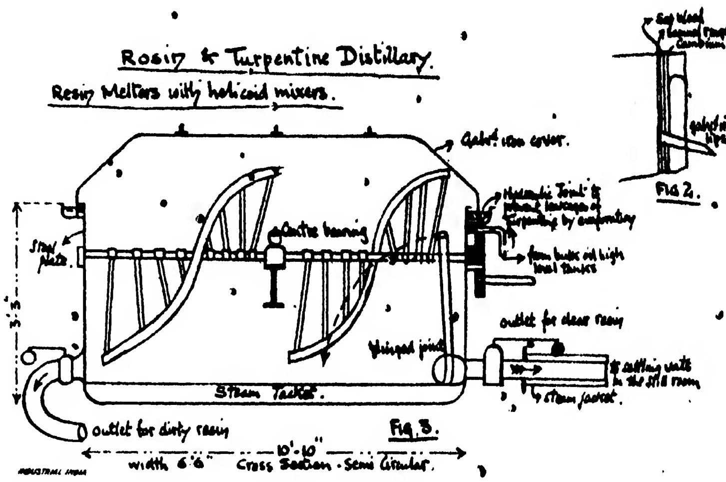


FIG. 1



Figs. 2 and 3

The usual tapping season is from January to October. The first two months are utilised in marking trees and making arrangements for collection and transport. The chief point to be attended to in organising a scheme of collection is to collect the resin as clean as practicable, and after collection to expose it to the atmosphere as little as practicable.

In February the required number of blazes are made in the marked trees. The loose bark, along with all similar inflammable material round the tree, is removed. This work must be done very carefully, as the resin, especially dry, is very inflammable. The coolies should be forbidden to smoke.

The Collecting Lip

The collecting lip, about 6 in. long, is attached to the base of the cut, and below it a nail is driven to hold the collecting pot. The resin, as it flows in the resin ducts, is collected in the cup. But after a time the flow stops, due to the blocking up of the ducts by gradual evaporation of the turpentine and the solidification of the rosin. The coolies in charge have instructions to freshen the blazes from time to time by removing a very fine layer of wood from the exuding surface of the blaze. By the end of the season the blaze has really increased to about 15 in. × 4 in. × 2 in.

The resin thus collected in the cups is transferred to the collecting depots, where these are emptied into tins, which are soldered air-tight after filling, and await carting to the nearest railway station for transport to the factory.

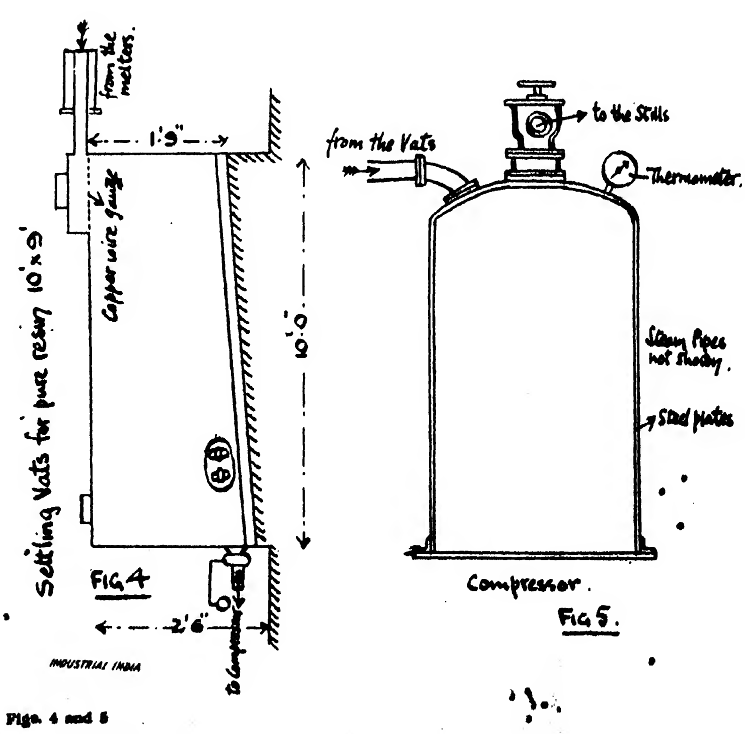
The coolies are paid by the quantity of resin collected. The main object is to empty the collecting cans into the tin at the depots as early as possible, so as not to expose the resin unnecessarily.

The resin tins arrive at the distillery usually by some light railway from the forest.

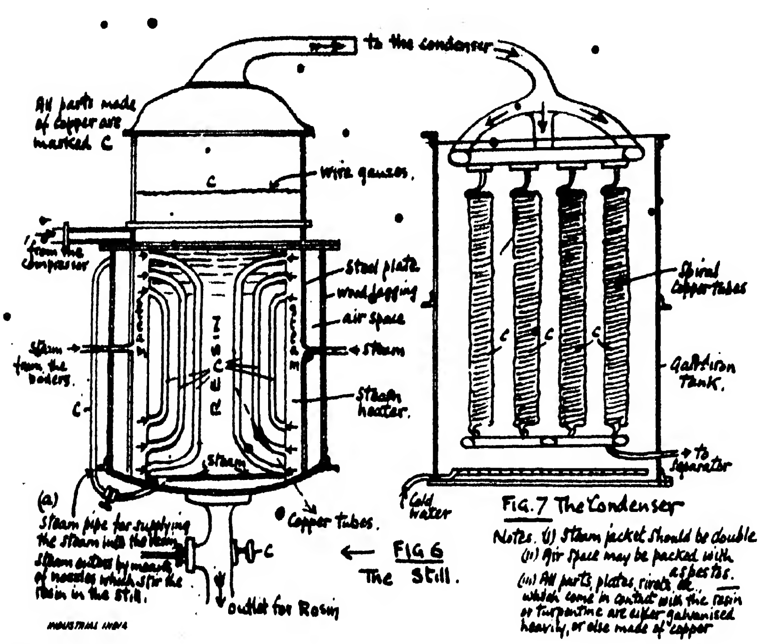
The Factory Process

In the factory these tins have to be stacked in cool and well-ventilated godowns. The floors of these houses have to be made with a camber to the centre, for collecting all the leakage from the tins.

From the godowns the tins, when required, are transported by trolley to the heating chambers (heated by a series of steam pipes). The resin is thus liquified in the tin, and the tins are next cut open in a huge



Figs. 4 and 5



Figs. 6 and 7

galvanized iron trough (steam jacketed at the bottom).

The resin is taken from this trough to the Helecoid melters. (See Fig. 3.) The capacity of the melters is approximately 1,100 gallons of resin. These melters are steam jacketed, as shown in the sketch.

To the above charge of the resin is added about 10 per cent. of its quantity of the bulk oil (turpentine) from special high service tanks.

It takes about two hours to mix and melt one charge of the resin thoroughly. The charge remains in the mixers for about fifteen hours. The lighter and purer quality of the resin is slowly drawn out by means of the hinged pipe shown in the sketch. About 40 to 60 per cent. of the total charge comes off as pure resin. The resin so drawn is led by mean of steam jacketed pipe to settling vats. (See Fig. 4.) The resin is further cleansed by passing it through copper wire gauze before admission into the storage vats, these vats being steam jacketed to keep the resin in a fluid state. The impure resin at the bottom of the melters is drawn off at the base. From this the pure resin is separated by means of a centrifugal machine.

The pure resin from the vats gravitates to the compressors. (See Fig. 5.)

The capacity of the compressor is usually 100 gallons. Under the pressure of the compressed air or steam, the charge of 100 gallons is forced into the stills. (Fig. 6.)

Here it is steam distilled under a pressure of about 110 lb. with 160 deg. C. temperature. The general principle involved is the well-known physical law of partial pressures. The turpentine evaporates along with the steam, which is admitted at the base of the still. (See Fig. 6a.)

One charge is thus distilled for about an hour and a half, when the steam admitted inside the still is cut off and the charge cooked for about twenty minutes, so as to evaporate all the moisture and turpentine from the residue in the still. This residue is an important by-product called rosin, which, along with shellac, is used for manufacture of varnishes, etc.

Separating and Classifying the Oils

This rosin is drawn off from the base of the still. It is pressed through lint and copper gauze to remove all impurities. This is then poured into casks, in which it solidifies, and is transported to the exporting godown.

The turpentine vapour, along with the steam, passes to the condenser. (See Fig. 7.) The vapours are condensed in the spiral copper tubes, round which cold water circulates. The mixture of water and oil is led to a separator. (Fig. 8.) They separate by their different densities. The finer quality of oil, which distills off first, is called "bulk oil," and the oil which comes off in the end, and is dirty looking, is called "inferior." They are collected separately. Both the oils are passed through C_aO and lime water to remove any trace of acidity. (See Fig. 8a.)

The bulk oil next passes on to the measuring drums, and thence to the storage tanks. From here the bulk oil is pumped to the high level service tanks, referred to above, whence it gravitates to the melters, or again to the stills for redistillation. The inferior oil is pumped directly from the tanks to the stills for redistillation.

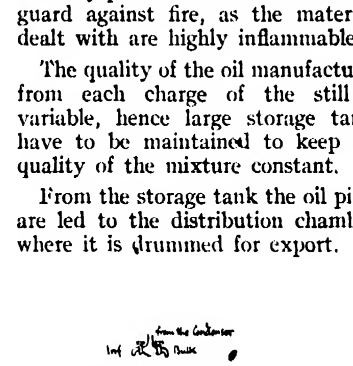
In the redistilling still the bulk oil (by fractional distillation) is separated in quality I and quality III oil. The inferior oil is divided into quality II and quality III oil.

The oils are next led to measuring drums, and thence to the storage tanks, in specially constructed chambers away from the main factory.

Every precaution must be taken to guard against fire, as the materials dealt with are highly inflammable.

The quality of the oil manufactured from each charge of the still is variable, hence large storage tanks have to be maintained to keep the quality of the mixture constant.

From the storage tank the oil pipes are led to the distribution chamber, where it is drummed for export.



This industry at present is national, in so far that it is not a private concern, and the huge profits yielded by it go to the public treasury. Like the rest of the Forest Department, the responsible work connected with the industry has been kept in charge of Europeans. But with the "gradual" Indianisation of the public services, this industry may pass wholly under Indian management.

Art in Bridge Design

IN a recent issue of *Steel Structures*—the quarterly journal of the Steel Structural Section of the British Engineers' Association—there appeared an article on "The Art Spirit in Bridge Structures." The writer laid down, as a sort of axiom, that an assurance of permanence is the prime condition of all art. We could, of course, quote a thousand instances against this contention. What about the modern poster, the up-to-date creations in which we attire our women, the settings of our stage productions, or the design of a Cross-Atlantic liner? Because the butterfly flits across the stage to-day, and is dead to-morrow, Mother Nature does not stint her form, colour, or opulence. Everything ugly, unsuitable, and ill-designed has a deadening effect upon the mind of man, and, therefore, it should be taboo in any civilised community. We have sometimes thought that the gantries and cranes which were raising tier upon tier of steel girders and concrete slabs were more pleasing and imposing than the modern buildings which were under erection. We would retain the beauty of the plant—although it is here to-day and gone to-morrow—and urge a greater beauty in the permanent structure itself. Our writer maintains, that when, in the insolence of his pride, Pietro de Medici commanded Michael Angelo to make an image of snow, his order remains for ever "the supreme example of wastefulness." We wonder! If this is so, then we must cut out the charming work of Phil May, Bernard Partridge, and Raven Hill. These men pandered—if you like—to the mood of the moment; but their influence will be a "joy for ever." Your true artist does not stop to think about the relation of his work "to the eternal constitution of the universe"—whatever that may mean! He does not concern himself in the "vested interests" or "the commercial spirit," except that, if he is a wise man—and more often he is—he demands a Roland for an Oliver. Usually having some sense of form, colour and fitness, he exploits that sense to his own advantage and, incidentally, to the advantage of the community at large. The old picture of the artist in a garret is played out. I usually find him in a well-lighted studio with a goodly appointed flat attached—and this is as it should be. However, to return to our muttons, the writer of the article under review contends that the iron and steel structures of fifty or sixty years ago were ugly because the designers conceived them to be of a merely temporary or industrial nature. We may forget the early users of steel if they did not realise its "noble qualities and high artistic uses," but we must not altogether forgive them. Many of our industrial problems to-day are a result of their indifference.

Let us admit, with the writer, that structural engineers, as well as their employers, had a good deal to learn and that they could not be expected to realise the "art" side of their business. Anyhow, "with the example of the Forth Bridge in its harmony with the Tower of London before them, both parties realise clearly the art possibilities of the bridge of metal structure. Many metal bridges now show all the beauty of arch and curving lines so long considered possible only to the bridge of stone or timber. With growing confidence in the permanence of their work, engineers have given much thought to the artistic quality and its outward appearance, and with 'love and delight' design grace and ornament for arch and buttress, pillar and finial. No material is so well fitted as steel to convey the idea of easy and secure flight over space, which is the artistic spirit of a bridge." There remains no excuse for us to ignore the artistic possibilities of the material with which we are working. Ugliness is a sin, and there seems to be no reason for keeping it alive in any of our engineering structures.

Curing Noise in Machinery

Noise is not only distracting to the ear, it represents a waste of energy. Therefore it is to the interest of machine makers to design their machines so that they run as quietly as possible. This aspect of engineering production has received very careful investigation by a British engineer, who has devised a very simple apparatus for tracking the noises to their source. The apparatus resembles a telephone receiver, and is connected by thick rubber tubing to a pair of ear tubes. A thin steel rod is connected to the diaphragm of the telephone so that sounds transmitted through the rod are heard. By applying the end of the rod to different parts of the machine, it is possible to locate noises very much as the doctor locates wheezes and murmurs in our breathing and blood-pumping machinery. By using two rods and two telephones, comparisons can be made between two noises; thus the running of a machine may be compared with the running of a standard similar machine kept in perfect order. Another development of the apparatus enables the intensity of sounds to be accurately measured. One of the most useful applications of the instrument is in detecting faulty portions of machinery before serious mischief has been set up.

A Brief Survey of Industrial India

(*Continued from page* 478.)

MORE ABOUT LAC

We have already made passing reference to the lac industry. Also we have said in effect that one of the disturbing features of the commercial life of India is that many industries, once in a lucrative and flourishing condition, are now practically extinct, and yet, under proper and up-to-date management, there exists no reason why they should not be profitably revived.

One of these industries is the lac industry—which is probably one of the oldest in India,—and is one of those which has passed through many vicissitudes of fortune. The use of lac in India has been common from the very earliest days; it has always been prized for its bright red colour, and its name still survives as "crimson lake."

To very many people lac and shellac are merely words conveying little or no meaning. They know they are something to do with commerce, but beyond that they are blissfully ignorant. The word "lac" is supposed to be derived from the Sanskrit lakrha (Hindi lakh), meaning "a hundred thousand," and was so applied to describe the myriads of minute lac insects which swarm like ants and settle upon trees, sucking their juices and exuding a white substance of a cottony nature which covers the twigs of the trees upon which the insects have settled. By degrees this white colour assumes a reddish tint, and becomes thick, and forms in layers which are stripped off the twigs twice a year. This crop is known to the trade as "sticklac." The life history of these little insects is full of interest, but cannot be noted here beyond mentioning that their products are of two kinds: (1) *lac*, which consists of a mixture of waxes and resinous substances; and (2) *lac-dye*, consisting of at least two dyestuffs which are concentrated in the body and eggs of the insect. A careful analysis shows that these little insects are capable of supplying all the Shellac requirements of the world for many years to come, if only a better and more intensive system of cultivation was adopted, despite the rapidly increasing foreign demands.

None of the districts in India where lac is most extensively cultivated are in any sense of the term intensively worked, and consequently the amount produced annually is far below what it could be. Not only has the industry dwindled owing to the apathy shown in its development, but the introduction of foreign substances, pollution and adulteration, have to a very large extent marred its prosperity. Fifty years ago, owing to the introduction of vegetable and chemical substances, the genuine lac dye trade dwindled practically to nothing. Exports from India in 1868-69 were valued at eight lacs of rupees; ten years later they had decreased by one-half in volume, and in value to two lacs of rupees. Fortunately, however, the interest in the dye has been transferred to its resinously-produced lac, which is so extensively used for varnishes, polishes, electric requirements, gramophone records, etc. In 1889 the exports of lac dye had practically ceased, but the export of manufactured lac, or shellac, which is lac manufactured in flake or "shell" form, were valued at nearly thirty-two lakhs of rupees. Ten years later these figures had increased to over seventy lakhs, and in 1908-09 the exports totalled nearly two and a half crores of rupees.

The war affected the industry both in value and direction. In 1912 the total exports were 254,000 cases, the then largest purchasers being the United States (111,000 cases), Germany and Austria (635,000 cases), and Great Britain (50,000 cases).

During 1919 the total exports reached 205,000 cases, the United States being the largest, and Germany the smallest purchaser. The demand in both the Western world and America is on the increase. India practically holds the monopoly of the genuine article, but India's methods must be modernised and brought up-to-date, and production must be intensified and increased.

The Report of the Indian Forests' Department for 1921, dealing with shellac, says: "The propagation and collection of lac are still primitive and uneconomic, manufacture is useless, and adulteration rife. A wider knowledge of scientific cultivation, and a closer organisation are necessary to establish the trade." Given these, there is no reason why the lac industry should not speedily be revived and become one of the greatest and most lucrative industries in India.

Irrigation a Vital Problem

One of the most vital questions affecting every country, and more particularly a country with a climate like India, is the water supply. One need not dwell upon this obvious fact, or debate at length upon the evil effects of an inadequate water supply. Suffice it to say that the world generally is waking up to the fact that although scarcity and resultant famine has often caused untold misery and loss, very often in the very countries most afflicted by these disasters, millions of tons of water have for centuries been going to waste.

This truth having once been realised, engineers got to work to devise means of conserving the water supplies of the world, not only for the relief of the people and cattle, or from agricultural reasons, but also because it has been found what a valuable power hitherto wasted can be harnessed to the chariot wheels of commerce. India has suffered untold misery in the past from water shortage, and her land has suffered more, in paucity of crops; failure of harvests, and bad condition of cattle, than probably any other inhabited part of the world.

England, in the past, has done much for India, but possibly the most valuable and lasting work she has

accomplished is to be found in the different irrigation schemes that are now in operation, or projected, practically from one end of the country to the other. It is impossible to overestimate the importance of agriculture in India, and its growth, with all that growth implies, is dependent upon the prosperity and extension of the irrigation system. Strong prejudices existed against any attempt at irrigation, as, in fact, it still exists against all new ideas, especially those imported from the West, but India has at least learnt something of the incalculable benefits to be derived as a result of a practical system of irrigation, and the old existing prejudice against it may be said to have died out.

In 1919 the total length of main and branch canals and distributaries from which irrigation work was carried out was over 66,120 miles, and these channels irrigated an area of over twenty-five million acres out of a total area possible for cultivation of about fifty million acres. During the same year fifteen additional schemes were under construction at an estimated cost of nearly 26 millions, and further plans for extension involving an expenditure of 36½ millions are now before the country. Thus it will readily be seen that India, however slowly she may move in some things, is keenly alive to the priceless benefits of irrigation.

In the Punjab alone, nearly nine million acres of land are dependent for their water supply upon the systems of irrigation. Until the early eighties canal construction had been confined to the more populated parts of the Punjab, but later, attention began to be given to the drier districts and waste lands, and it is stated that during the last twenty-five years 270,000 acres have been added annually to the irrigated portions of the Province. At the present time over 15 per cent. of the total cropped area is irrigated by Government irrigation works, and great has been the financial cost of their works, but the estimated value of the crops in a single year is said to exceed by more than 25 per cent. the total capital outlay expended. From Madras Presidency, Bombay, Bengal, and the United Provinces, in fact throughout the whole of India, come reports of activity and enterprise in the irrigation work, and stories of benefits already obtained therefrom.

The Four Methods of Irrigation in India

Irrigation in India is chiefly carried out in one of four ways. The first method consists of putting some form of barrage across a river which has a perpetual flow throughout the year. By this method water can be diverted through a canal into the area which it is desired to irrigate. The great perennial canals of Northern India are mostly constructed on this method. A second method which prevails in the majority of the canals in Sind, and also in many of those in the South-West of the Punjab, consists in leading canals direct from the rivers into the desired areas without constructing any form of barrage. A third method consists of building a dam across a valley, and thus storing the monsoon rains, the water so imprisoned being distributed by a system of canals to the neighbouring country. These reservoirs vary in size from the tiny ponds—or tanks—in small villages to vast works in the Western Ghauts, with dams of masonry up to 270 feet in height. The fourth method used is by lifting water from wells by means either of the old leathern bag hauled by bullocks or of more modern means by power-driven pumps.

In allotting Government funds for irrigation purposes, all irrigation schemes are classified under one of three headings: (*a*) Productive, (*b*) Protective, (*c*) Minor Works. Before any one of the schemes can be classed under the first heading, it must give sufficient ground for believing that within ten years of completion the revenue derived from such a scheme will cover the annual interest charges upon the capital invested. The amount expended under this heading in 1918-19 as capital outlay amounted to 38.7 millions, exclusive of amounts spent upon canals used exclusively for navigation. The total receipts amounted to 5 millions, and expenses reached 2.75 millions, so the nett profit for the year amounted to 2.2 millions, or about 5.7 per cent. upon the original outlay. Irrigation works classed under the heading of Protective include works which are constructed for the protection of precarious tracts, and which, though not directly remunerative, yet guard against the necessity for periodical expenditure or relieving the population in times of famine.

Up to the end of 1918-19, the capital outlay on works of this description amounted to £7,000,000. The local receipts for the year, including land revenue due to irrigation, amounted to over £107,000; and the total expenses, including interest, to £325,000, the net loss amounting to just over £218,000, or a loss of 3 per cent. upon the capital outlay.

Under the heading of Minor Works are included works not either directly productive or protective, but which, including agricultural works, are undertaken for the general improvement of the country. These result in an annual profit of about £169,000. By these systems of irrigation vast deserts have been turned into fertile lands, and busy peasants now till lands which previously had lain unproductive and waste. One such—among the latest—project deserves special mention, viz., the great scheme known as the Krishnaraja-Sagara scheme, by means of which the surplus waters of the River Cauvery will be imprisoned and made available both for irrigation purposes and for hydro-electric power.

Irrigating Half-a-Million Acres of Land

An unfortunate dispute arose between the Governments of Madras and Mysore, from a fear that the scheme might result in an inadequate supply of water for their lands which lie below the dam. This dispute has now been settled, and the work is progressing. The vastness of the scheme may be gauged from the fact that it will comprise a dam and a canal 78 miles long. When the dam is completed it will be 120 feet in height, and will store 41,000,000,000 cubic feet of water, and form a lake over 40 miles in circumference and cover nearly 30,000 acres. When the full height is completed, the water supply will be sufficient not only to meet all the demands for electric power, but will also provide irrigation for over half a million acres of land.

The scheme necessitates submerging either partially or wholly about twenty villages with a population of over 10,000 people, and it was of course necessary to provide homes for these people, and they have all received adequate compensation, and have been settled in districts where houses have been erected for them on the plan of model villages. The great dam is to be built in two stages, the first stage consisting of 4,200 feet, though the foundations for this have necessitated 4,750 feet being laid. When completed, it is expected that

the dam will contain nearly 30,000,000 cubic feet of masonry. A number of sluices 12 feet by 6 feet have been built in the dam 12 feet above the bed level, and by these means an adequate supply of water is supplied to the Madras territory. Long irrigation channels penetrate the Mysore territories, and many canals have also been made, or are in process of formation. One of these canals in process of construction is to be taken across the Hulikere - Karighatta hills by means of a tunnel nearly two miles in length. After crossing these hills, the canal will extend about seventy miles, and irrigate a large tract of country, at present practically waterless. In addition to a weir, a waste weir is also being made which will be 1,800 feet long, and which is to conserve the excess waters of the monsoons, the overflow from these being diverted to the river. The whole project is conceived on a great scale, and it is very much to the credit of the local engineers that it is being carried out entirely by their own men without any outside assistance. From what has been written, it will readily be seen that the old prejudices against new ideas, at any rate so far as irrigation is concerned, are things of the past, and that the Indian agriculturist is now fully alive to the benefits to be derived from it. The effects upon the whole country, both as they influence crops and benefit the cattle, and also in the physical improvement upon the people, cannot be measured. The moral effects of famine upon a people, its disheartening and demoralising influences, play a very important part in the development of a country's industries and resources, and any means that can mitigate this evil and minimise its recurrence are valuable adjuncts in that country's agricultural and industrial advancement.

It is a good augury, therefore, for the industrial future of India to know that not only are her peoples awakening to the benefits of irrigation, but that the respective Governments are also acting sympathetically in this as in other matters affecting the material prosperity of the country.

Notes and Comments

GAS PRODUCER PROGRESS

In our May issue we printed an article on "Modern Gas Producers," illustrating and giving a brief description of the Kerpely mechanical gas producer.

As is our rule, we gave the writer of the article a free hand to deal with the subject as he desired, but he would appear to have gone out of his way to belittle the progress in the development of mechanical producers in Great Britain as compared with America and the European Continent. It might be readily inferred from his remarks that the Kerpely mechanical gas producer is only of recent construction, whereas the Kerpely revolving grate producer with mechanical ash discharge was actually first introduced into England in 1910, and was readily taken up by many of the largest steel works. The mechanical feeds of Messrs. E. G. Appleby & Co. were first added to the Kerpely producer in 1912. If a comparison of these dates is made with the history of gas producer progress in America and on the Continent, it will be found that England was not behind, but well in front in developments in this direction.

* * *

SUPER-MACADAM ROADS

About one hundred years ago the British road engineer Macadam laid down the soundest principles upon which road surfaces should be formed. He advocated the use of small angular stones, none over a certain size, laid on a road and gradually rolled flat by the traffic. By this means he obtained a wonderfully firm well-drained road with excellent wearing qualities. In spite of the development of concrete roads, the macadam type is still in vogue, and it has received a new lease of life in this age of automobile traffic, through the use of a tar coating over each and every stone. This coating serves to bind the road together, and to make it dustless and water-proof. Until lately the usual practice was to mix the material with tar by hand, but a British firm of road engineers has designed, with a view to efficient operation on a large scale, a plant which first dries the materials and then thoroughly mixes them with tar. This plant is capable of turning out one hundred tons of treated material in a day of eight hours with a driver and a boy looking after the actual operation. The only additional labour required is in conveying the material to the receiving end and in taking it away from the discharging end. This plant, which is driven by a 15-h.p, portable engine, consists of an elevator, drying barrel, and automatic dipping gear. The engine which drives the plant also supplies steam for drying purposes. Semi-portable plants of the same kind are made to deal with twenty or with fifty tons per day, and a larger fixed plant of 200 tons capacity has also been designed. Even the large plant, however, is made so that it can be readily taken to pieces and put up again in order that it can be moved from quarry to quarry as required.

RAILPLANE TRANSPORT

In our next issue we propose to describe the new method of rapid transport by means of the patented George Bennie Railplane System. This method would appear to open up very important possibilities in solving some of India's most urgent transport problems. It dispenses with the use of a track laid on the ground, and is little affected by the undulations of the country. The carriages being driven by means of air propellers, enables an arrangement whereby friction is reduced to a minimum when running at speed. The carriage virtually becomes a controlled airship without the risks of a self-supported vehicle, while retaining the capacity for very high speeds.

MANUFACTURES

Conducted by J. D. TROUP, M.I.MECH.E. & GEO. T. TAVENNER, A.I.E.E.

THIS SECTION DEALS WITH THE PROCESSES, METHODS, AND DETAILS OF MANUFACTURE INCLUDING MACHINE TOOLS, WORKSHOP PRACTICE AND MECHANICAL APPLIANCES

Low Temperature Carbonisation (xiv)

(THE LIQUEFACTION OF COAL)

BY DAVID BROWNLIE

B.Sc. Hons. (Lond.), F.C.S., A.M.I.Min.E., Mem. Am. Soc. M.E., A.I.Mech.E., etc.

IT will not be without interest to include in this series of articles an account of the remarkable work now being undertaken with the object of converting coal bodily into a liquid fuel of the nature of crude petroleum, chiefly by the absorption of hydrogen at high temperatures and pressures. This is, of course, not low temperature carbonisation at all, but as one of the objects of the latter is the production of the maximum amount of oil from coal, the complete liquefaction of coal is certainly an analogous operation requiring the most careful consideration, particularly as it relates also to subsidiary treatment of low temperature oils, and opens out the prospects of a complete revolution in the whole fuel question.

The pioneer in this direction is Dr. F. Bergius, of Mannheim, in Germany. About ten years ago Bergius commenced research work in connection with the constitution of coal and the production of an artificial coal substance, following on the earlier work of various chemists, particularly Stein and Klason.

Bergius heated cellulose, peat, and similar vegetable products in autoclaves at about 1,500 lb. pressure and 640 deg. F. (340 deg. C.), under which conditions cellulose, after about 12 hours, was converted into a black powder containing 84 per cent. carbon, 5 per cent. hydrogen, and 11 per cent. oxygen, with the evolution of CO_2. It was found also that this reaction obeyed the usual chemical law, a rise of 50 deg. F. (10 deg. C.), doubling the rate of the reaction, so that the product from cellulose for 64 hours at 590 deg. F. (310 deg. C.) was the same as that for 8 hours at 640 deg. F. (340 deg. C.).

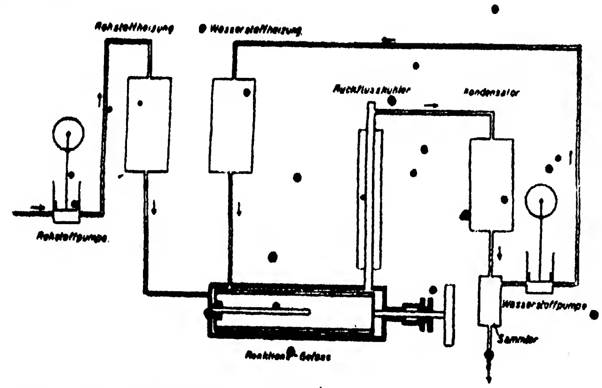
Bergius calculates therefore that average coal has taken 8,000,000 to 10,000,000 years to form in the earth. The earlier workers in this field could never get an artificial coal with as high a percentage of hydrogen as real coal, but Bergius has had no difficulty in this respect, because he placed his high pressure autoclaves in water. The high thermal capacity of this medium enabled the heat evolved by the highly exothermic nature of the reaction in the autoclave to be absorbed at once, and so prevented the formation of coke by excessive and uncontrolled internal temperatures.

Bergius found the greatest difficulty, however, in raising the carbon content of his artificial coal over about 85 per cent., but by the use of incredible and dangerous pressures—in some cases no less than 5,000 atmospheres (75,000 lb.)—a figure of 88 per cent. was obtained in a number of cases, methane being then evolved as in the coal seam in the earth.

It was in the progress of this work that Bergius discovered that his artificial coal would combine with hydrogen, and that by the action of the latter at very high pressures of 200 atmospheres (3,000 lb.) and temperatures of 840 deg. F. (450 deg. C.), a considerable volume of hydrogen was absorbed, and the solid product converted into a thick liquid analagous to crude petroleum. He soon applied this reaction to real coal, and found the same reaction took place, namely, that coal in a pulverised condition at high temperature and pressures absorbs a large amount of hydrogen, and is converted more or less into liquid substances with a much higher hydrogen content.

The process was also applied on a commercial scale to the hydrogenation of oils, that is, converting heavy oils—petroleum or otherwise—into much lighter and more volatile oils by hydrogenation. It will be interesting to give a very short description of the large scale methods employed for oils at the works with which Dr. Bergius is associated, the Deutsche-Bergin A.G., at Rheinau, near Mannheim, so as to understand better the position as regards the liquefaction of coal.

The oil is first examined experimentally in the laboratory to find the best conditions for hydrogenation on a large scale. A small 5-litre steel autoclave is used, in which is placed a weighed amount of the oil, and hydrogen is then pumped in at any desired pressure and the autoclave sealed. It is then revolved at about 60 revolutions per minute in a horizontal position, fixed to a rotating shaft, and heated by powerful gas jets. The pressure developed is enormous, often as high as 200 atmospheres (3,000 lb. per square inch), and the operation is conducted in a small heavy concrete chamber with all the controls electrical, and operated at a great distance in case of accidents. The whole is then allowed to cool, the autoclave opened, and the liquid product analysed, whilst



Diagrammatic View of Autoclave and Pumps

the amount of residual hydrogen is also determined.

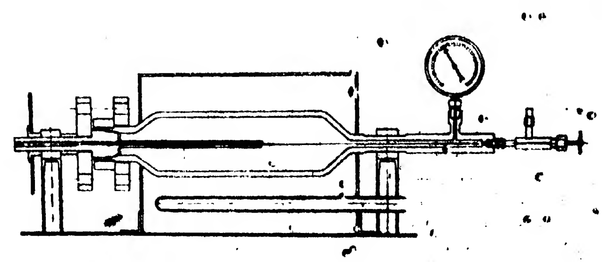
The oil is then treated on a large scale, according to the same proportions that have been determined experimentally, in heavy steel autoclaves, generally with a capacity of 1 ton of oil per 24 hours. The construction of this autoclave, although many points are not clear, is obviously of the most ingenious character, being 30 ft. long and 3 ft. internal diameter, having a replaceable steel liner with a special dephlegmator at one end, and provided also with an internal mechanical agitator. The heating of this autoclave, an extraordinarily difficult problem, is by high pressure nitrogen gas at the required high temperature passed between the outer casing and the inner lining. The oil, heated also to a high temperature by the exit nitrogen in coils, after passing through the autoclave liner, is pumped continually into the autoclave at high pressure, together with hydrogen gas, the liquid contents being mechanically agitated. As the hydrogen is absorbed, the lighter and more volatile hydrocarbons formed escape into the dephlegmator, whilst the heavier liquid residue in the autoclave is withdrawn continuously. In this way 50 tons of oil can be treated in 24 hours in the complete installation without any trace of carbonisation or "scaling" of the autoclave. The operation is carried out by distance electrical controls in a heavy building completely isolated, and so far no serious accident has occurred.

As typical of the results, a Mexican crude oil with 6 per cent. volatile below 410 deg. F. (210 deg. C.) after one hour's hydrogenation gave a product of 42 per cent. volatile under 410 deg. F. (210 deg. C.), and a wide range of oils has been treated. It is obvious, therefore, that this remarkable process is of very great interest, if only because a large part of low temperature oils could thereby be converted into volatile hydrocarbons of the nature of motor spirit, and the necessity of a high yield of the latter, say 3-4 gallons per ton of coal, would therefore not be so important as is generally thought.

With regard to the application of this method to the direct liquefaction of coal, the difficulties are much greater. Coal is of course a solid, and even when pulverised to a very fine degree, does not enter into anything like so intimate a contact with the hydrogen as a liquid like oil, so that a long time, 12-15 hours, is necessary for hydrogenation, even to the extent of say 60 per cent. of the coal. Also it is very difficult to control the temperature and avoid the formation of coke products, because, as already pointed out, of the strongly exothermic character of the reaction. However, some of these difficulties have been overcome in the most ingenious manner by pulverising the coal and suspending it in heavy oil, so that the colloidal fuel mixture is circulated with a high pressure pump like ordinary oil.

The results of a very large amount of work on these lines by Bergius is that the most favourable conditions for the hydrogenation of average coal is 100 atmospheres (1,500 lb. per square inch) and 750 deg. F. (400 deg. C.), so long as the percentage of carbon in the coal on the ash-free basis does not exceed 85 per cent. Coals of the nature of high grade anthracite (over 85 per cent. carbon) do not absorb hydrogen, or only with the greatest difficulty, whilst charcoal (pure carbon) gives no reaction. Average coals, when treated at 750 deg. F. (400 deg. C.) from 40-200 atmospheres pressure, according to quality, form a complicated liquid which seems to be almost identical with crude petroleum, and which, in the same way, can be separated by fractional distillation into a wide range of organic compounds. The oxygen present in the coal forms a range of phenols, and it is stated that the whole of the nitrogen is converted into ammonia or ammonium compounds, and the sulphur into sulphuretted hydrogen.

Whether the Bergius method for the hydrogenation of coal can ever be a commercial success remains to be seen, as of course the plant is costly, complicated, and dangerous, whilst the influence of wear and tear, and the effect of the ash, can only be told by experience. At any rate, the results already achieved are undoubtedly amongst the most remark-



Laboratory Autoclave

able ever obtained by the technical chemist, and further progress is bound to result.

It would seem probable that a most likely development in the immediate future in the hydrogenation of coal is in the use of catalytic agents to enable the reaction to go on at more reasonable temperatures and pressures. Thus a somewhat similar process is carried out in the "hardening" of fats in which hydrogen is absorbed in the presence of catalysts, so as to increase the hydrogen content of the fat and alter its properties with a view to increasing the commercial value.

It is understood that something on these lines is being attempted by H. Magnus, of Freiberg, in Baden, in which pulverised coal or lignite is passed continuously in the presence of hydrogen through a retort containing two catalysts at quite moderate pressures and temperatures, with a large absorption of hydrogen, but no details of this process are available. The same applies to the "Steinschneider" process in Czecho-Slovakia, at Köningsfeld, which is supposed to be a distillation process at ordinary pressures, in which the large amount of liquid obtained is then further treated with hydrogen for additional absorption.

Another interesting method suggested for the hydrogenation of coal is to generate the hydrogen in the nascent stage in an intimate contact with the coal, since, as is well-known to chemists, so-called "nascent" elements (that is, immediately when formed) are more chemically reactive than when in the ordinary state. The chief workers in this field are F. Fischer and H. Schräder, who use sodium formate. This salt, on heating to 680 deg. F. (360 deg. C.), generates hydrogen, and since the volatile matter of lignite begins to decompose at 610 deg. F. (320 deg. C.), their experiments have chiefly been carried out with the object of hydrogenating lignite. Thus an intimate mixture of one part pulverised sodium formate and four parts of pulverised lignite is heated for three hours at 750 deg. F. (400 deg. C.) at ordinary pressures in a current of steam, when 23-27 per cent. of the lignite is converted into a liquid product.

If this reaction is carried out at a very high pressure, 200 atmospheres, a larger yield is obtained, equal to about 44 per cent. of the weight of the lignite. It was found also that many factors alter the yield. Thus moisture in the coal plays an important part, and variations in this respect alter the proportion of the liquid product soluble in ether from about 1½-10 per cent. without interfering very much with the total oil yield. In the same way the temperature of the reaction effects the percentage soluble in ether, being, for example, about 28½ per cent. soluble when at 660 deg. F. (350 deg. C.), 45 per cent. at 750 deg. F. (400 deg. C.), and only 8.0 per cent. for 840 deg. F. (450 deg. C.).

It is a very interesting discovery in this connection that the percentage of ether soluble constituents depends also on the age or rank of the coal. Thus a given anthracite coal gives about 1½ per cent. soluble and a highly volatile coal 39 per cent. There is also considerable difference in this respect between various lignites.

An entirely different general method for the liquefaction of coal is by oxidation. Thus F. Fischer heats pulverised bituminous coal at 445 deg. F. (230 deg. C.) for 10 hours with a strongly alkaline solution, such as soda ash, in a current of compressed air or oxygen at 30 atmospheres, generally using iron or manganese salts as catalysts. Under this treatment the coal substance is almost entirely decomposed, and the volatile matter largely forms highly complex organic fatty acids which are dissolved in the alkaline solution, and a large amount of gas also results, apparently containing resinous materials analagous to turpentines. Further results in connection with the liquefaction of coal generally will be awaited with great interest.

The Structure and Heat Treatment of Steels

(*Continued from page* 664)

and ductility. The means of attaining a good structure by heat-treatment alone will be apparent from Fig. 4. Having heated the steel above the critical temperature, it will be seen that there is a complete obliteration of the originally existing grain, and a progressive increase in the grain size of the resulting solution, depending on the rise in temperature. The size of the grain thus formed is not changed during the reverse cooling process.

For practical purposes it is generally necessary to heat forgings to a high temperature in order to facilitate work being done on them. This results in the formation of a coarse grain unless precautions are taken to prevent such a structure. If, however, these grains are broken up due to some outside influence such as mechanical work being done on the metal, for instance, hammering or rolling, and this action is kept up continually till such time as the temperature of the metal drops as near as possible to the critical zone, the result will be that we shall obtain a fine grained structure in the finished metal, the fineness of the grain being dependent on the amount of mechanical work put in and the close adjustment of the finishing temperature.

The physical properties of this fine grained metal are again affected by the degree of tempering performed upon it, and the two processes must be co-related if good results are to be obtained.

If now the reader has been led so far into this most fascinating and important subject that his interest has been sufficiently aroused to induce him to probe yet further into the question on his own account, the object of this paper will have been served.

A Portable Moulding Machine

All illustrations in this article are by courtesy of Messrs. Macnab & Co., London

FOR rapid repetition work in the foundry, the modern moulding machine has firmly established itself, just as the automatic tool has established itself in the machine shop.

In this article we give a brief description of one of the many different types of the "Tabor" patent moulding machine, the functioning of which is clearly seen from the illustration. It is claimed with this machine that any mould within its capacity can be jar rammed in about 30 seconds, and that the operations of jarring the mould, rolling the mould over, vibrating and drawing the pattern ready for the next box, does not occupy more than two minutes. This claim gives a good idea of what a moulding machine means as a time-saver.

This model is made in two standard sizes, as follows :—

Size ... in.	18	24
Straight pattern draw ... in.	8	10
Size of moulding box ... in.	18×30×12	24×48×15
Net weight of load which can be rolled over at 80 lb air pressure ... lb.	450	800

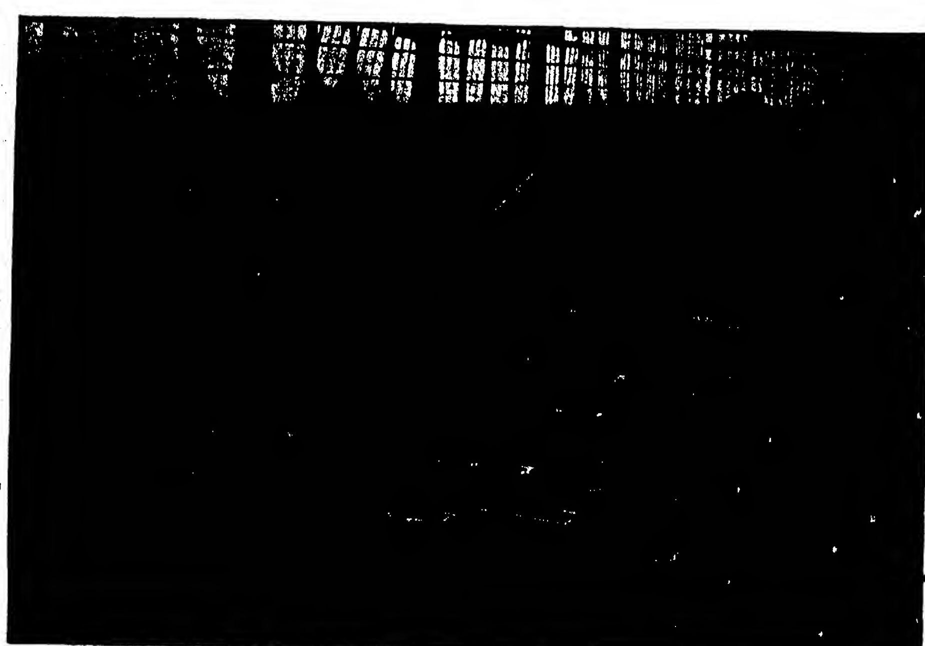
This is an ideal moulding machine for general railway work castings, such as axle boxes, brake shoes, etc., and it is in successful use in the majority of the best known foundries in Great Britain, and machines have also been supplied to India and other countries.

It is suitable for the economical production of practically all classes of castings within its capacity, such as castings for motors and dynamos, cisterns and brackets, electric fuse boxes, gratings, gearboxes, crank cases, cylinder castings, fly-wheels, exhaust manifolds, radiator tanks and similar work, back axle castings, valves, and many other classes of work too varied to enumerate. It is claimed that there is scarcely a job which cannot, with a little planning, be economically produced on this machine, provided the load is within its capacity.

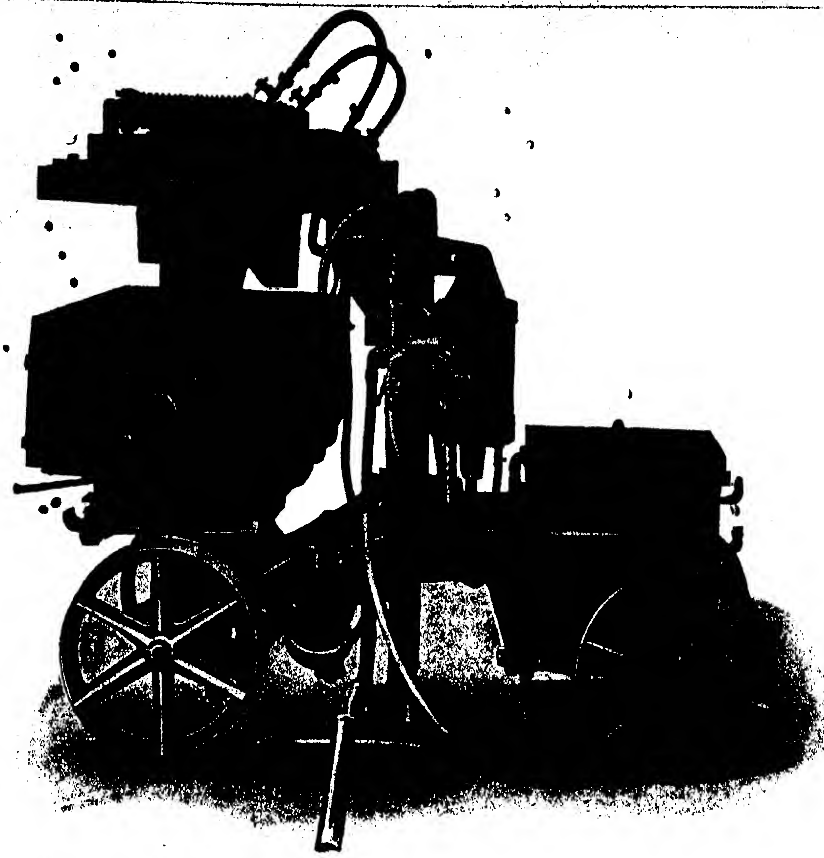
Ramming the Sand

Its dominant feature is that the ramming is performed by a "Shockless" operation, which, whilst ensuring the most efficient ramming of the sand, accomplishes this independently and without shock to the rest of the machine, the pattern board simply resting on the jarring table, and being held in position by means of two dowel pins, thus facilitating rapid and easy change of patterns.

With the actual mechanical operations of the machine for each mould



Motor Castings being made on Tabor Combination Jar and Roll-over Moulding Machine



The Pattern Drawn and Ready to Roll Back
(The Pattern is drawn up from the Mould)

Snap Flasks may also be used on Tabor Combination Jar and Roll-over Moulding Machine

only being two minutes, the question of production is therefore practically entirely dependent on foundry organisation and the facilities available for handling sand, and bringing the moulding boxes to the machine, and taking away as soon as completed, and the speedier the arrangements, naturally the greater the output.

The machine specially appeals to foundrymen on account of its simplicity rendering it possible to be operated by unskilled labour. Another great feature and advantage is its extreme flexibility, and boxes of different sizes up to the specified load capacity of the machine (*i.e.*, 450 lbs. 18 in. machine, 800 lbs. 24 in. machine) can be handled by the machine, such loads being calculated on the basis of even distribution over the area of the table.

In one foundry an output of 86 boxes per day is being obtained on one of the 18 in. machines, with three Great Eastern Railway chairs in a box, *i.e.*, 258 castings, but, as already explained, this is such a speedy machine that the output obtainable is practically only limited by the organisation and facilities for handling boxes, etc.

The firm make many other different models for dealing with castings weighing from ounces up to 25 tons, and will be glad upon receipt of blue prints of heavier castings to send particulars of other machines to any of our readers who are interested.

Methods of Manufacture

In addition, Messrs. Macnab would be willing to offer advice in regard to the present methods of manufacture, if readers will advise them how their castings are at present being produced. If they consider the present methods are the best, they will say so, or otherwise submit a proposition covering their recommendations for consideration.

It should also be specially emphasised that the use of this machine is not restricted to any particular size moulding box, and any size box can be used, provided the total load specified is not exceeded. The specified load is calculated on the basis of even distribution over the area of the table, and subject to this reservation, larger or smaller boxes may be used on the machine over a wide range.

We would like to point out that Messrs. Macnab & Co., of 56-58 Eagle Street, London, W.C.1., are the sole manufacturers under licence and suppliers of these machines in India, and also sole suppliers and actual manufacturers for Great Britain.

WAGON POOLING TO BE CONTINUED ON INDIAN RAILWAYS

We heartily congratulate the members of the Indian Railways Conference Association on their decision to continue the wagon pooling scheme for a further period. Although it is admitted that there are certain disadvantages in the scheme, especially from the point of view of certain railways, such as the Bengal-Nagpur, the inherent advantages attaching to wagon pooling are so extensive as to warrant a continuance of the system that has been so productive of economy. Both from the standpoint of the trader and manufacturer, as well as that of the railway companies generally, the economies accruing from wagon pooling justify every effort to retain this method of working, and it is to be noted in this connection that in other countries, having a much larger wagon stock than that in India, wagon pooling has been held to be distinctly beneficial. Under existing circumstances in India, where there is an admitted shortage of wagon stock, it is difficult to understand any objection to continuance, but that objection, strong objection, has been made, is obvious from the President's remarks at the Railway Conference. In our opinion, it may just as well be said now, as later, that the trading community demand the continuance of this system of working, as it is impossible to tolerate the old - time method, which deprived many traders of their legitimate transport demands being met.

RAILWAY ELECTRIFICATION IN INDIA

The news that the Indian Government have sanctioned the electrification of part of Bombay's suburban railways is of considerable interest, as the vital need for an expansion of the transportation facilities in that congested area has long been manifest. The sanction applies to the lines of the Great Indian Peninsula Railway, and the section to be electrified includes the lines running from Victoria Terminus to Thana, and the harbour branch which reaches Kewri through Sewri. It is probable that the development of this scheme of electrification will impel the Bombay-Baroda and Central India Railway to arrange a similar scheme, and in that event Bombay will be admirably served by its suburban lines. The many great advantages of electrification are now being increasingly recognised where the traffic conditions call for the more effective provision of facilities, as it has well been proved as a result of experience, that it is in the long run cheaper to electrify than to continue an indefinite expansion of track facilities such as that called for under steam working when track capacity is reached. The Bombay scheme and its fuller development will be watched throughout India.

Modern Methods of Rivet and Screw Production

By E. HERBERT LYNALL

All illustrations in this article are by courtesy of Messrs. Vernon Proctor & Co.

A BRIEF glance at the British Board of Trade export figures should interest anyone contemplating the manufacture of rivets, screws, bolts and nuts, etc., in India.

The huge quantities of these goods exported annually from Great Britain, exclusive of similar goods imported from America and Japan, would go to prove that an excellent opportunity awaits the enterprising firm who will consider the installation of a modern plant.

A great deterrent in the past has been the fact that raw material has by necessity been imported, but with the growth of the steel industry in India, this difficulty is likely, in the near future, to be entirely obviated.

Wire rods will no doubt be produced in India, and the next step is the manufacture of bright drawn wire. To deviate temporarily from the subject in hand, it might also be noted that an equally valuable opportunity is presented in the manufacture of wire. Bright drawn wire has innumerable commercial uses, and in a country whose industrial develop ments are growing, a secure business footing is assured to the firm which commences to draw wire from Indian material. The basic material obtainable is of very excellent quality, and with modern plant and methods an immediate market would be assured.

Rivet and Screw Production Machines, etc.

The aim of modern constructors has been to combine simplicity in detail with high productive capacity. In most constructions, safety devices have been embodied which render them easily operated by ordinary mechanics, and up-to-date manufacturers have information to give regarding tooling, the class of steel to be used for same, heat treatments, etc. This information, being available to buyers of plant, enables them to commence production with the elimination of the mistakes usually made when dealing with unfamiliar work.

We propose in this article only to deal with the machinery for producing rivets, screws, etc., by the cold process, as it is obvious that hot process machinery requires treating in a separate article, the respective methods being entirely apart.

The greatest development in rivet and screw production has been achieved in comparatively recent years, and it may be stated that up to a certain point the progress was slow on account of the prejudice existing against a "cold worked" product.

The economical limit of the "cold process" is up to ½ in. diameter, after which the "hot process" becomes operative, as beyond this size rolled bar material can be used.

Cold Heading Machines for Rivet Making

These machines can be divided into two classes, namely, solid die type and open die type. The former type of machine, as illustrated in Fig. 1, is necessary for the production of "snap" head rivets or rivets which require to be perfectly smooth underneath the head, and where fins would be objectionable.

The drawn wire of suitable ductility is passed through straighteners to the feed rolls, and automatically fed into the machine, when the desired length is cut off by means of a cutter knife actuated by a cross slide. A spring finger holds the cut-off blank in position against the recess in the cutter knife, which advances and transfers the cut-off blank to a point in line with the heading die. The heading slide then moves forward, and the punch enters the blank into the die, the cut-off knife and spring fingers receding to give full movement to the advancing punch. The punch completes its forward movement, and the head is formed. With the receding of the punch slide, the headed rivet is ejected from the die by means of a cam-actuated knock-out plunger. During the ejection of the rivet another blank is being fed to the desired length and cut off, the cycle of operations being continued.

This machine attains a speed of 200 per minute on ⅛ in. wire, to 120 per minute on ¼ in. wire.

In general practice the limit of a solid die machine is its power to eject the headed rivet, and it is

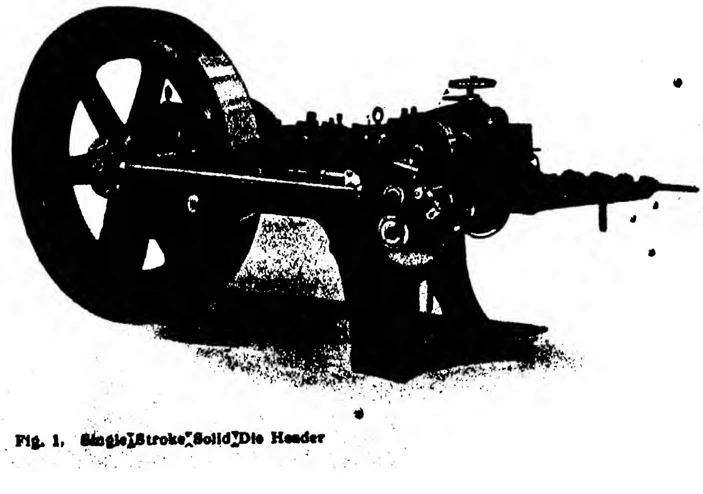


Fig. 1. Single Stroke Solid Die Header

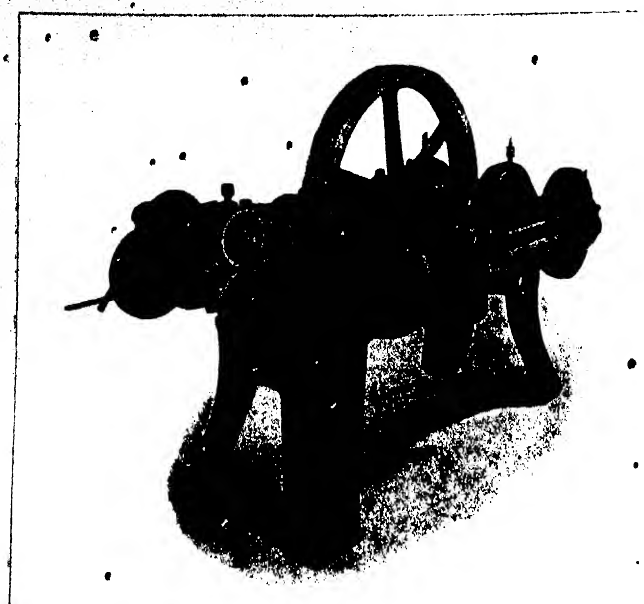


Fig. 2. Single Stroke Open Die Header

generally accepted that the length of shank should not exceed eight times the diameter of the wire. Any departure from this rule puts an undue strain upon the knock-out pin, and difficulties are likely to be experienced, but up to eight times the diameter of the wire the ejection is performed with a smooth action, and the wear upon the die is very slight.

The open die machine, as its name implies, is a machine having the heading die in two halves, and is applicable to work where the fin caused by the split dies is not objectionable. The dies are actuated by toggle mechanism, and the wire, being fed between the dies by means of feed rolls, the toggles cause them to grip the wire. The heading dies in this case also serve as a cut-off, and, moving sideways from the feeding line, the blank is cut off and moved into position in line with the advancing heading punch. When the action of heading has been performed, the dies again move sideways and are slightly opened, and the advancing wire then ejects the finished rivet or headed blank.

It will be at once apparent that ejection is no difficulty in this case, and consequently the operating speed of the machine is slightly higher, but owing to the dies having to perform the cut off of the blank, the depth of the dies is the limit of the length of shank.

It will be understood that in the case of the solid die the length of the shank can be varied up to its full

Fig. 3 Triple Stroke Solid Die Header

capacity. The only limitations regarding length of work to be handled in an open die machine are such mechanical limits as feeding, and the stroke of the heading slide. Except in special cases, heading machine makers have standard sizes which cover the lengths generally in commercial use relative to the diameter of the shank.

The type of machine in general use for rivet work is the single blow header, as the standard rivets come within the heading limit of a single blow machine, the amount of stock possible to upset with a single blow being generally recognised as two and a half times the diameter of the wire.

A company in whose products the author is interested, is about to put on the market a machine which has many novel features which recommend themselves to firms who require a machine to cover a large range of work. This heading machine has for its qualifications the merit of being an open and solid die header capable

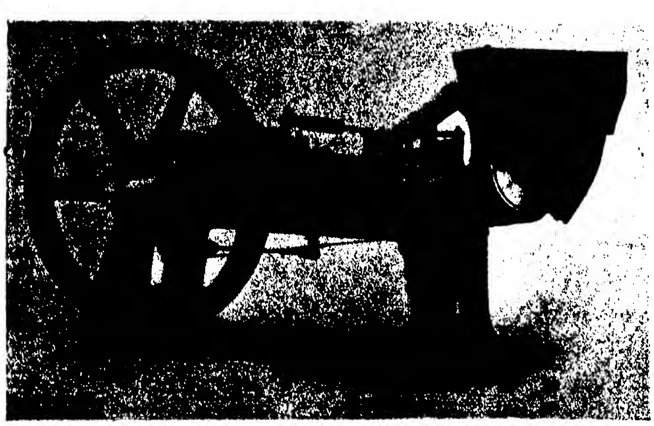


Fig. 4. Automatic Bolt Trimming Machine

Fig. 5. Galco Thread Rolling Machine. Type 5

of being used for single, double, or triple blow work, and it will be seen that this machine will handle a range of work requiring six headers of ordinary type. When using this header for open die work, the range of its utility is considerably increased by reason of the fact that all lengths can be made in one pair of open dies. This is explained by the fact that the blank is cut off and transferred to the dies, as with a solid die machine, a positive knock-out plunger acting between the dies.

Double and Triple Blow Headers

It has been mentioned that a single stroke heading machine is capable of upsetting only two and a half times the diameter of wire, and this type of machine is practically limited to rivet work, but when, some years ago, machines were designed to give two and three blows, the range of cold heading was immediately enlarged.

With two blows four and a half diameters can be upset, while a triple blow header increases the limit to six to eight diameters. This can be taken as the extreme limit of cold heading, and up to this point ductility of the material must be assured in order to produce good results.

Successful and uniform heading with these machines depends largely upon the pre-shaping blows, in order that the final blow given to the stock does not have a deleterious effect upon the material. When the stock has been correctly gathered or coned, the finished head or upsetting will show a regular flow with the material evenly distributed.

The making of blanks for hexagon and cup square screws requires careful tooling, but by adhering to the simple rules governing this class of work, standardisation in tooling can be effected.

While not in general use, the triple blow machine gives a more latitude on account of the extra opportunity given for pre-shaping. In this case the final blow is not excessive, and a more even production is obtained, which, in the author's opinion, more than discounts the slightly lower production rate. The triple blow header is preferable, therefore, when large upsettings have to be made. The double and triple blow machines (either open or solid die type) are operated as in the case of single blow headers, but gearing effects the necessary timing of the cut off relative to the feed, etc., and a punch lifting mechanism gives the necessary movement to the punch slide.

Fig. 3 gives a side view of a solid die triple blow machine, and this has the same appearance as a double blow header, the only difference being in the gearing, the punch slide, and cams operating same.

Hexagon and square-headed screw blanks are first forged with a round head, a secondary operation being necessary for trimming. This operation is performed by an automatic trimmer of single or double blow type, an example of the latter being given in Fig. 4. The headed blanks are placed in the hopper of the trimming

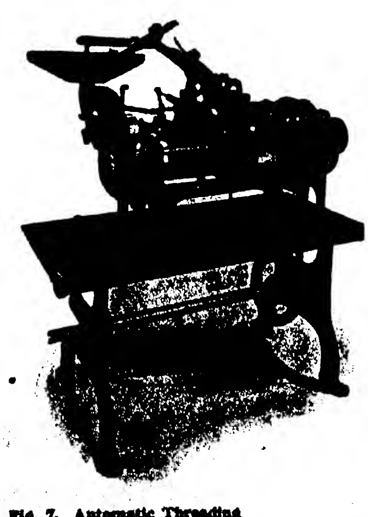


Fig. 7. Automatic Threading and Pointing Machine

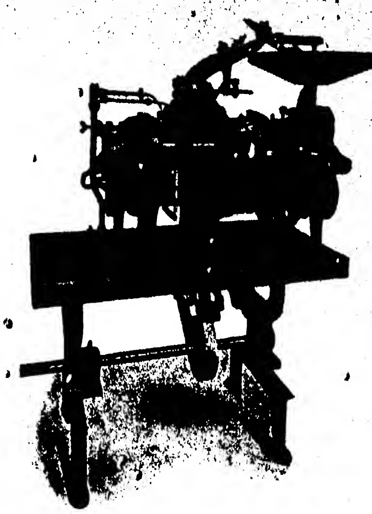


Fig. 6. Automatic Shaving and Slotting Machine

machine, which, by means of an elevating pick-up blade and feeding fingers, conveys the blank to the trimming die. The slide holding the trimming punch then advances, and the headed blank is clipped to the desired shape.

Thread Rolling Machines

The thread rolled screw is growing rapidly in favour, and for many classes of work is displacing the more expensive automatic screw machine-produced article. From the point of rapid production alone, the rolled thread commends itself, but it is worth while recording that repeated tests have shown that the rolled thread possesses about 15 per cent. greater tensile strength than screws made with automatic screw machines. In the case of screws made with the latter type of machine, the structure of the material is broken, whereas the thread on the thread rolled screw is produced by an operation similar to cold swaging, and the crystal structure of the material is not broken, but a compressing action takes place. When compared with a screw turned from bar material, the strength of a rolled thread is even more pronounced, as in this case the thread is actually cut upon the core of the material, which is, of course, the poorest quality.

Thread rolling machines are obtainable for both hand feeding and for feeding automatically, the latter process naturally being much faster. One operator can attend to six automatically fed machines, which require very little supervision other than

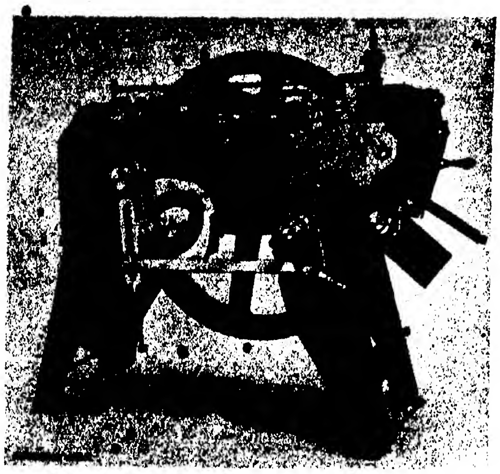


Fig. 8 Cold Pressed Nut Machine

the feeding of the blanks into the hopper.

In operation, the blanks are placed in the hopper of the machine in which an elevating pick-up blade is working, which takes up the blanks by their heads and lifts them to a point in line with the feeding chute, when the blanks fall by their own gravity down the chute to be fed between the threading dies.

The Bofors machine (Fig. 5) has an ingenious method of checking the blanks in their movement down the feeding chute. The blanks are held by a checking finger which allows them to fall one by one to a point further down the chute, where each single blank is checked a second time. With the next forward motion of the reciprocating slide, this blank is allowed to drop to the bottom of the chute, where it is positively entered between feeding fingers. These fingers lightly grip the shank of the screw blank, which is then carried to the threading dies in a perfectly upright position.

This machine makes the operation as mechanically perfect as it is possible to obtain, and the chance of mishap to the dies on account of two blanks being fed at the same time is entirely eliminated.

Wood Screw Machines

Special attention must be called at this point to the enormous quantity of wood screws which are imported into India, and were a firm to equip themselves for supplying the whole demand of the country, they would need a plant which would cost many hundred thousand pounds. The author emphasises this fact in order to point out where the most important opportunity for Indian manufacturers lies. In order to obtain a thoroughly balanced plant for making wood screws, a production of at least 80 gross per hour should be aimed at, as up to this point the production from the various machines does not balance, and the labour employed is not absorbed to its fullest economic capacity. It is very necessary also that the plant should be well laid out, and auxiliary machines for drying and cleaning the screws, etc., as well as the arrangements for counting and packing, should be carried out according to the instructions supplied by the makers of wood screw machinery.

The first step in the making of wood screws is the heading of the blank, which is performed by an open die heading machine (Fig. 2). In this case the fin caused by the opening of the dies is not objectionable, as a subsequent operation shaves the head clean of all fins and burrs, etc. The headed blanks are placed in the hopper of an automatic shaving and slotting machine (Fig. 6), which shaves the head and puts the slot in same, and the blanks from this machine are then taken to the threading and pointing machine (Fig. 7), which automatically feeds and points the end of the blank and cuts the thread upon it.

These two machines are fully automatic, and one operator is able to attend to a large number. After being thus treated, the screws are cleaned, dried, and then taken to the sorting and packing bench, where they are placed in packets ready for warehousing.

The wood screw trade should command the attention of manufacturers who contemplate entering the screw trade, as there exists in India an ever-growing market for these articles, and the raw material which is being produced in India is eminently suited to this class of work.

Cold Pressed Nut Machines

As in the case of rivet and screw manufacture, the economical limit of cold pressed nut making is ½ in., and up to that size the cold process machine, as shown in Fig. 8, will produce good quality articles with rapid economy. The machine shown in the illustration is a double blow toggle acting machine, which has a great advantage over single acting machines for this purpose.

The stock is passed through straightening rolls and pierced, the blank being then cut off, chamfered, trimmed and ejected from the machine. The main feature in these machines is the very efficient way of trimming the lateral faces of the nut. This is not accomplished by merely cutting off the waste material, but is performed by a combination of pressing and burring which produces a nut with a perfect finish, smooth faces, and full sharp corners, the blank being produced ready for the tapping operation.

The output of this type of machine is from 70 per minute for 5/16 in. nuts to 45 per minute for ½ in.

In the foregoing the writer has endeavoured to outline briefly machines of modern construction now in use. It is, of course, difficult to treat the whole subject of rivet and screw production fully in one article, as the subject is a very wide one, but if an opportunity is presented at a later date, it may be possible to give an article dealing with the technical and physical side of the subject, when the result of many interesting tests would be shown.

If the reader of this article is interested sufficiently to make further enquiries regarding the possibility of manufacturing rivets, screws, bolts and nuts, in India, the best advice offered is that they should put themselves in the hands of first-class and substantial makers of this machinery, as only such firms are able to give the purchaser the full advantage of their many years' varied experience in the development of this trade.

The Structure and Heat Treatment of Steels

By R. C. CASE, A.M.I.C.E.

(Indian State Railways)

A simple explanation of the main principles involved in the application of the more or less complicated heat-treating processes which are rapidly becoming everyday practice.

So much has been said and written regarding the structure and heat treatment of steels, that it is difficult for the ordinary engineer to get an intelligible idea of the subject. The majority of the most recent publications on the subject deal with it in such a detailed and highly technical manner, that men equipped with an average degree of engineering training either cannot understand the technicalities, or find the details of insufficient practical importance to be worth bothering about. The subject is necessarily a very highly specialised one, and it is hardly to be expected that the average engineer should be able to appreciate many of the technicalities involved. His attention is required in the consideration of many other equally important problems.

On the other hand, it is highly desirable that the practising engineer should understand the main principles involved in the application of the more or less complicated heat-treating processes which are rapidly becoming everyday practice. Unfortunately there are very few schools and colleges which include such subjects in their engineering syllabuses, and it is generally left to the engineer to pick up what he can about the subject from experience, and from miscellaneous literature to which he has access, and to secure satisfactory results by following carefully the instructions for treatment which steel-makers often issue with their products.

It will be the purpose of this article to present in as straightforward a manner as possible such aspects of the principles of the subject as will be of interest and help to the practising engineer who has neither the time or the opportunity to study the matter more deeply.

It will be advisable to review some of the more important matters concerned with alloys in general before proceeding further, in order that we may have a perfectly clear general idea of the subject in our minds before taking up the particular complicated constructions and variations met with in the series of iron and carbon alloys which are considered in this paper.

General Considerations

There are very few of the pure metals which, unalloyed, are physically suited for employment in engineering construction. Consequently, they are blended with various ingredients with the object of enhancing the properties of one or any of the constituents in the resulting alloy. The manner in which these ingredients mix together is very variable, and it is possible with suitable proportions and suitable heat-treatment to vary the properties of the alloys within very wide limits.

In the first place, the constituents of an alloy may be found to be associated in a state of purely mechanical mixture, and although existing in a coherent mass, may be made up of particles entirely dissimilar. The strength of such an alloy may be varied by altering the degree of fineness in the aggregate, the shape of the particles aggregated, the nature of the binding medium, and so on.

At the other end of the scale we may have such an intimate connection between the constituents of the alloy, that they become chemically combined to form what may be considered as an entirely different substance, and one that may possess entirely different properties to any of the original constituents.

Between these two extremes there come the more usual cases in metallic alloys, where there is only a partial loss of the individual properties of the original constituents, although these constituents may be mutually blended together to an extent which defies visual detection. Chemical combination may have taken place to a greater or less extent, depending on the substances alloyed, conditions of temperature, and other factors.

Where such partial chemical union and loss of individuality takes place, we refer to the mixture as being in a "solid solution." The properties of such solutions compared with the properties of the original constituents depend to a large extent upon the degree of solubility, which may range between the two extremes noted above of "mechanical mixture" and "chemical combination." Examples of such cases are to be found in all the alloys in common use, such as the brasses, white-metals and steels.

It must be understood that the fact that the constituents of an alloy are perfectly miscible in the molten condition is no criterion that this will be the case after solidification, while even after solidification the degree of miscibility may be considerably affected by conditions of temperature. This matter has a most important bearing on the treatment of steels, as will be explained later.

In addition to the variations, outlined above, we may get allotropic modifications in the ingredients of alloys which will have a pronounced effect upon their mutual solubility. Allotropy has been defined as "a change in the properties of an element without a change of state." Such change is habitually accompanied by a change of internal energy, and is attributed to a molecular rearrangement of the atoms in the molecules of the substance concerned. Carbon, for instance, as is generally known, can exist in allotropic modifications

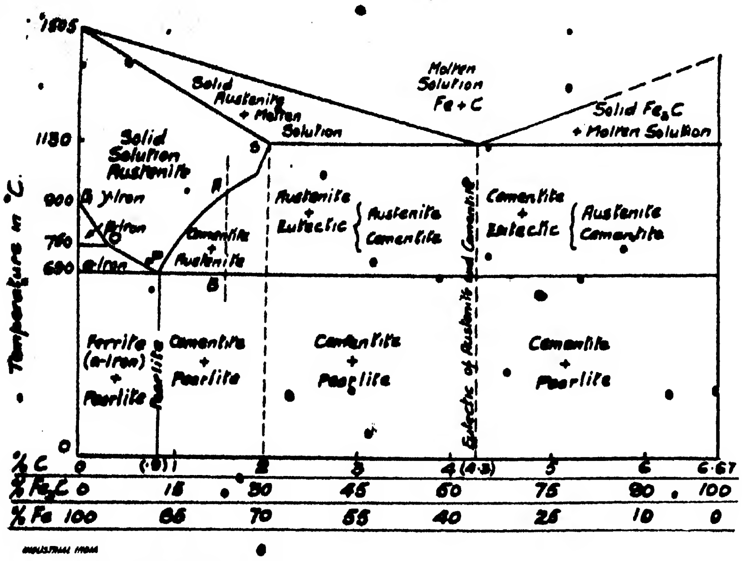


Fig. 1. Roozeboom Diagram for the Solubility of Iron-Carbon Alloys

as carbon, graphite and diamond. The change of internal energy accompanying such transformations is fairly easily demonstrable, and such changes are indicated in the Roozeboom diagram for the solidification of iron-carbon alloys which is shown in Fig. 1.

The structure of metals is crystalline and the formation of these crystals on solidification is analogous with the formation of crystals from ordinary solutions of salts. This analogy has led to the formulation of what is known as the "solution theory," and, for the purposes of this paper, this theory has been chosen from the number of theories available as being sufficiently probable, and also as being comparatively easy to understand. This theory will help us to understand the process of "selective crystallisation" or "freezing" referred to below. It is on the size of the crystals and their degree of cohesion along their boundaries that the strength of steels and other alloys depend to a considerable extent.

Homogeneity in the mass of an alloy will be secured by diffusion. The rate of diffusion of the constituents of an alloy will be retarded as the temperature drops, and in the case where "selective freezing" takes place, such selection will take place over a range of temperature, depending on composition and other variables, as indicated in Fig. 1 by the dotted line AB. The temperature range lying between 1,000 deg. to 690 deg. C. will be that through which this "selective freezing" takes place in the case of a steel containing about 1.6 per cent. of carbon.

It follows, then, that changes in the rate of cooling over such temperature ranges may effect material changes in the composition of the resultant alloy. Such effects may be compared with the sorting out of a number of men in a crowded room into, say, two different parties. Up to a certain limit of time such a separation could be effected without the slightest confusion or inaccuracy, but should the time factor be cut down unduly, individuals of the crowd will be jostled out of their places, and it may even be impossible to separate out the different parties completely. The degree of jostling and entanglement of the two parties will depend on the time available for their separation. In the heat treatment of steel, full advantage is taken of the possibility of either assisting or retarding this selective process.

The Iron-Carbon Alloys

In commencing a more detailed consideration of the iron-carbon series of alloys, it must not be forgotten that chemically pure iron is never found in commercial life; it is essentially a product for the research worker. But we get iron alloyed with various elements, by far the most important of which is carbon. Other elements will, of course, affect the properties of the resultant alloy, but we can ignore their effects for the present. We want to get at the underlying principles of the case by the shortest possible route.

For the purposes of this examination, steel will be considered as a simple binary alloy of iron and carbon. Solubility will be considered as being complete in the liquid state, and partial in the solid. The formation of a "eutectoid" alloy, which term is explained below, marks the point limiting solid solubility, and between this point and the liquid condition, "selective freezing" may take place. Within the limits of this selective freezing, homogeneity of structure may be produced through diffusion, but beyond the limits of solubility there will be found a eutectoid alloy associated with the alloy formed in the primary crystallisation stages. The alloy formed in the primary stages will be a saturated solid solution of either component of the alloy saturated with the other, while the eutectic will be a solution of a fixed composition made up of the two components of the alloy each saturated with the other.

Iron, combined with carbon, forms a compound called by metallurgists cementite, which is often referred to by chemists as iron carbide, and given the formula Fe_3C. It is also referred to sometimes as combined carbon, to differentiate it from uncombined carbon or graphite, in which state carbon is found mechanically associated with cast iron. Cementite is the hardest constituent of steel, and contains 6.67 per cent. of carbon. It is very brittle, and quite the opposite in properties to ferrite, or pure iron, which is relatively soft and ductile, with a tensile strength of about 23 tons per square inch.

Before we can fully appreciate the points illustrated in the Roozeboom diagram (see Fig. 1), it must be understood that in alloys there is a certain mixture of the constituents containing the "eutectoid" proportions, which will give the lowest solidifying point from the molten state of all mixtures of those particular constituents. In addition, it will be as

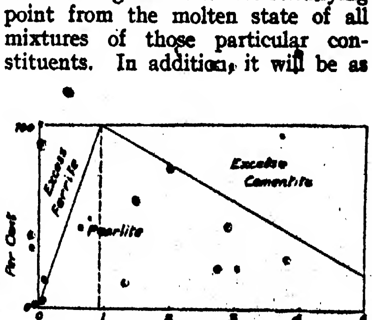


Fig. 2

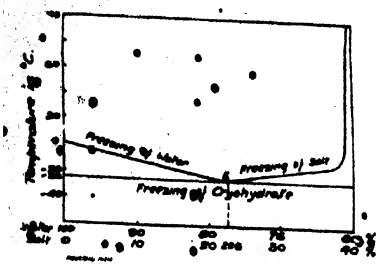


Fig. 3. Cooling Curve for a Salt Solution

well to illustrate some of the more striking phenomena connected with the formation of alloys by considering the analogous case of a salt solution.

It is easy to demonstrate that if a salt solution is sufficiently lowered in temperature, ice will form at first if the mixture does not exceed 23.5 per cent. of salt. This separation of water will increase the percentage of salt until at last the concentration is such that the cryohydrate composition or "eutectoid" point is reached, when the whole mixture freezes solid. The reverse applies if the original solution contains more than the eutectoid proportions of 23.5 per cent. salt, in which case the salt will begin to crystallise first. The super-saturated salt solution is referred to as a "hyper-eutectoid" solution, and the under-saturated solution is referred to as a "hypo-eutectoid" solution.

An iron and carbon alloy in the eutectoid proportions is called pearlite, and contains 0.89 per cent. carbon. From what has been said regarding salt solutions, it will be seen that eutectoid steels might be expected to be made up entirely of pearlite, hypo-eutectoid steels of crystals of ferrite embedded in the eutectic pearlite, while hyper-eutectic steels would be made up of cementite embedded in the eutectic pearlite. Broadly speaking, this is what actually occurs. The diagram (Fig. 2) will serve as a convenient reference in this direction.

Returning to our salt solution, suppose we subjected the solution to an even degree of cooling, and plotted the temperature/composition curve for the solution, we should get a curve similar to that shown, in Fig. 3. At 0 deg. C., with a hypo-eutectoid solution, there would be a retardation in the rate of cooling due to the evolution of latent heat given out during change of state of the water into ice. If we continue the cooling and plot the positions where these changes in the rate of cooling take place, we shall eventually find the point E where at a temperature of —22 deg. C., the cryohydrate proportions are reached, and the solution solidifies as a whole. Should the cooling be continued further still, the whole mass will cool down at an even rate. Very similar effects can be observed by taking pyrometer readings of the changes which take place in the cooling of steels.

The Roozeboom Diagram

We will now return to our consideration of the Roozeboom diagram. From the data given along the abscissa of the curve, we see that for every 1 per cent. of carbon, 15 per cent. of cementite (Fe_3C) is formed. The series of mixtures containing over 2 per cent. carbon on the right side of the diagram are not of practical interest to us, as such mixtures can hardly be considered as steels in practice. We can then confine our attention to the left side of the diagram.

Taking the more obvious points illustrated in the diagram first of all, we find that, from the temperature scale along the ordinate, the melting point of pure iron is 1,505 deg. C. The temperatures 900, 760 and 690 deg. C. mark points of retardation in the cooling of the metal at which the iron is considered as being in the allotropic modifications generally referred to as "Gamma," "Beta," and "Alpha" respectively. With these modifications we are not concerned at present. The point at 690 deg. C. is often referred to as the "recalescence point" of the metal, and is the point where the most marked change in the rate of cooling takes place. This point marks the solidifying point of the eutectic pearlite.

Austenite is a solid solution of Fe_3C in Gamma iron, in which the Fe_3C may be held in solid solution up to 30 per cent. at 1,130 deg. C., the point marked S, but from this point selective decomposition takes place, along the line PS, in a manner analogous to our salt solution, and there will be a primary settling out of excess cementite. With austenite of a composition below 0.9 per cent. of carbon, decomposition will occur somewhere along the line GOP, the ferrite settling out from the austenite according to the proportions of the alloy; these changes will be completed on reaching the eutectic temperature at P.

Should the alloy contain 0.9 per cent. carbon, no change in the austenite will occur until the point P is reached, when the cementite and ferrite will separate out simultaneously, forming pearlite. Should the conditions of cooling be favourable, there will be a certain degree of coalescence between the ferrite and cementite formations, resulting in the lamellar structure readily recognisable in micro-photographs of such structures. These lamellæ consist of exceedingly thin alternate strata of cementite and ferrite. Should the temperature and other controlling

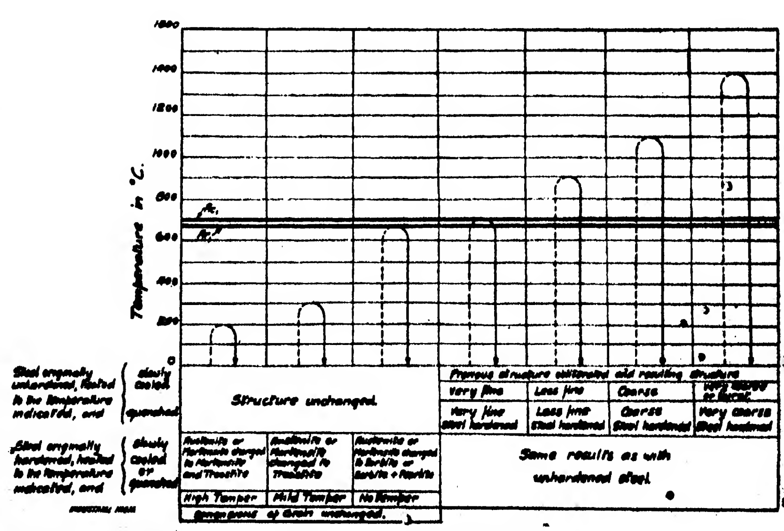


Fig. 4. Brinell's Hardening and Tempering Chart

factors be unfavourable for the formation of the lamellar pearlite, the structure may be granular.

The Structure of Steels

We are now on the high road leading to a proper understanding of the hardening of steels and their heat treatment.

There are a number of characteristic structures by which steel passing through its transitions from the solid solution to the ultimate simplest separation of cementite and ferrite can be recognised. These, taken in the order of their occurrence, are austenite, martensite, trostite, sorbite, and cementite plus ferrite. Each of these transitions marks a change in the characteristics of the steel under treatment, while, in addition, the metal exhibits considerable differences in appearance under the microscope. There are, however, no well defined limits of division, and this grouping is largely a matter of convenience in description.

It will have to suffice for our present purpose if we merely describe the most marked characteristics of the structures mentioned above sufficiently to make clear the changes in the physical properties of steels as they are subjected to various degrees of heat treatment. Micro-photographic examples of these formations can be found illustrating many of the articles on the structure of steels which appear in some of the leading technical journals, and a close study of the more representative examples will amply repay the student in the more intimate conception he will be able to form of the nature of these structures.

Austenite is normally found in steels at temperatures above the critical range, in proportions depending upon the percentage of carbon in the alloy, rate of cooling, and quenching temperature. Owing to the speed of transformation, it is only with the high carbon steels that it is possible to retain the austenitic condition in the cooled steel, and even then it is found in association with martensite. In conjunction with other elements such as manganese, tungsten, etc., however, it is possible to retain the austenitic formation entirely. Austenitic steels possess a polygnal grain structure, are non-magnetic, softer than cementite, and are rather ductile and tough.

Martensite is the first stage in the decomposition of austenite, and is the principal constituent of hardened steels. Its constitution is still a matter of controversy. It is obtained by quenching steels that are of, or above, the eutectoid composition from temperatures within the austenitic range. Under the microscope, the structure appears as a network of interlacing needles. It is extremely hard, strong and brittle, and non-malleable when cold.

Trostite is the next transition stage, and is obtained associated with martensite as a result of partial tempering after hardening, and also directly by quenching suitable steels at suitable temperatures. Microscopically, it appears as nodular formations associated with either martensite or sorbite. Its constitution is a matter of doubt, and its physical properties lie between those of martensite and sorbite.

Sorbite is the last state in the transition, and is considered to be a form of pearlite in a minute state of subdivision. Under the microscope, it appears as a uniform minutely granular formation. It is obtained either by direct quenching from suitable temperatures above the critical range, or by suitable tempering. Probably on account of the uniformity and fineness of the structure, steels in the sorbitic condition have high strength and elasticity and maximum ductility compared with those of normal pearlitic structure.

Heat Treatment

It is the arresting of the steel's transition in any of the formations outlined above that constitutes the art of hardening and tempering, and the general heat treatment of steels.

Now, the reactions described as taking place during the various transitions in the constituents of steel require a certain amount of time, and, broadly speaking, if only the time element can be made sufficiently short during the cooling process, it will be possible to retain the steel in either the austenitic or any other desired condition, owing to the fact that internal changes in the structure of the steel cannot take place after the steel becomes sufficiently rigid. Again, these transitions are reversible, and the reactions will reach a condition of equilibrium with rises and falls of temperature, as will be understood from the Roozeboom diagram.

It is a matter of common knowledge that a high carbon steel quenched out from a high temperature in cold water will attain a higher degree of hardness than one quenched out from the same temperature in oil. This is accounted for by the fact that there are differences in the viscosity, conductivity, and so on, of oil and water, and water is capable of conducting away heat from a body subjected to quenching at greater rate than oil. Consequently there will have been less time in which the transitions from the austenitic stage could have taken place, and the steel will retain its hardness to a more considerable degree.

Reference to a modified form of Brinell's chart (see Fig. 4) will render the position more clear, and also indicate the connections in grain structure and hardening and tempering that exist during the various transitions. The chart is very simple, and is self-explanatory.

It will be well to enlarge upon one or two points presented in the chart before going further. The temperature limit marked Ar_1 is the recalescence point of steel; this point manifests itself during the cooling of steel by an evolution of heat in the manner previously explained. The limit marked Ac_1 is the corresponding point occurring during the heating of steel where the rate of increase of heating is retarded owing to an absorption of heat through the allotropic modifications taking place. These points vary somewhat for steels of different compositions, but in any case are separated from one another by about 30 deg. C., the Ac_1 point being higher than the corresponding Ar_1 point.

Later research has shown that it is necessary to heat steels, particularly low carbon steels, to a point above Ac_1 before the desired changes are effected. But, generally speaking, having heated steel to a temperature Ac_1 or above, the previous structure of the steel will have no influence on any changes taking place at these temperatures and subsequently. On the other hand, the effect on the structure obtained by heating to a temperature below Ac_1 will depend on the carbon content of the alloy, and also upon its original structure before heating.

Generally speaking, the object sought after in heat treatment operations is the securing of the maximum possible fineness of grain, and it may be taken as axiomatic that fineness of grain is accompanied by good strength

(Continued on page 653.)

POWER AND POWER TRANSMISSION

Conducted by
J. D. TROUP, M.I.Mech.E.

THIS SECTION DEALS WITH THE SOURCES, USES AND TRANSMISSION OF POWER AND WITH THE DESIGN AND MANAGEMENT OF PRIME MOVERS OF ALL KINDS

The Problems of the Engine Indicator

BY LOUGHNAN PENDRED, M.I.MECH.E.

This completes the paper read by Mr. Pendred before the Institution of Mechanical Engineers, London, the first part of which we printed in our June issue.

WHILST, as already said, the pencil mechanism is the outstanding characteristic of the different indicators, we must beware of exaggerating its importance. Material differences exist between indicators which employ the same kind of straight line motion as, for example, between the Crosby "New" indicator of America and the Maihak of Germany. It will be seen that both employ the same pencil mechanism, but if we turn to other parts dissimilarities are at once observed. Both employ a spring in tension and a long hollow piston-rod, but whereas in the Crosby the piston is freely jointed to the rod, in the Maihak it is rigidly attached to it. In the Crosby, again, a ball on the spring takes the thrust, whilst in the Maihak a small crosshead is provided. Furthermore, the piston of the Crosby is barrelled, whilst that of the Maihak is parallel. In the Crosby we find, therefore, the piston endowed with the greatest possible liberty. In the Maihak it is given no freedom, for it is assumed that a spring in tension does not distort. The author's own view is that the free piston is the better of the two, and the simple ball-thrust of the Crosby appeals to him more than the little crosshead of the Maihak. Others no doubt will hold different views. An interesting feature of the German instrument, the splendid workmanship of which should be examined, is the careful heat-insulation of the spring.

In the Casartelli indicator the same pencil motion is used as in the Crosby and Maihak, but the spring is in compression instead of tension. The piston is mounted on a ball and a single helical spring is used. The piston is free to retain its parallelism with the cylinder, but since the spring is rigidly held at the top, any lateral distortion of it under compression would tend to thrust the piston against one side or other of the cylinder. This little weakness exists in nearly all indicators, and the only obvious way to overcome it would be to give the spring a spherical bearing at its abutment. As far as the author has been able to discover, the Crosby "New" indicator is the only one that allows the piston complete liberty.

Another detail of interest is the form of the indicator cylinder. In modern designs the cylinder is held in the casing at one end only by a screwed flange. The other end is quite free, and the walls, which are thin, do not touch the casing. This arrangement has the advantage that the cylinder is able to expand quite freely in a longitudinal direction, and fairly freely in a diametral direction. In this direction the stiff screwed flange puts some restraint on its movement. The fact that the steam or hot gases play about the outside as well as the inside of the cylinder reduces distortion.

The joints in the mechanism present another problem of great importance, not less as regards their wearing qualities than their number and accuracy. Since the multiplication effected by the gear is either four or six, it will be readily seen that any backlash in the joints may readily assume serious proportions. If it exists then the pencil, owing to its friction on the drum, remains up after the piston has begun to descend, whilst on the exhaust stroke it does not fall as far as it should. In other words, the whole card is displaced relatively to the true atmospheric line. Distortion of the card is also caused. It is unnecessary to labour the point, for it is quite obvious that any slackness must lead to indefinite defects.

Optical Indicators

It is of importance that the two purposes to which indicator cards may be put should be clearly distinguished. They are first the estimation of horse-power, and secondly, the examination of the cycle of events occurring in the cylinder. In the indication of steam engines and slow-speed internal-combustion engines the former is generally the ruling motive, but in the indication of high-speed petrol engines the second is generally the object sought. Indicators of the optical type are more properly regarded as research or laboratory instruments than as engine-room appliances. They suffer, as already noted, from lack of portability and from that simplicity of use which characterises mechanical steam and gas-engine indicators. It is impossible not to feel regret that a simple and

reliable indicator for extremely high speeds is lacking. It is common experience that in multi-cylinder engines all the cylinders do not work equally well, and the invention of an indicator which could be applied to such cylinders with the ease of the common mechanical indicators is to be desired.

The disk form of optical indicator has always attracted inventors from the time of John Perry up to Watson and Dalby. In instruments of the kind as usually made, the disk or diaphragm is its own spring, and as it is in direct contact with the hot gases, some doubt exists as to the constancy of the indications. It is held by some that the resistance of the disk diminishes as the temperature rises, others are satisfied that with a certain measure of cooling, as by water circulation in the casing, used by Watson, or by providing a large body of cooling and radiating metal as well, as used by Dalby, there is no material change due to a reasonable temperature rise. Beside the temperature effect on the resilience of the metal, the expansion of the disk must cause some distortion. In one form of indicator, that designed by the late Professor Robert H. Smith, the disk was retained as a spring only, the pressure being received on a light copper diaphragm.

Some doubt also exists as to the constancy of the scale of pressures when disks are employed. It is essential that the deflection per unit increment of load should be identically the same throughout the whole range of the instrument. Watson found that the scale was not constant with a flat disk, and he therefore used a corrugated one, and a corrugated disk is used by Dalby. Carpentier, on the other hand, retains the flat disk, but corrects the change of scale by an ingenious mechanical device.

Attractive as the disk form is, it has important disadvantages, amongst which may be mentioned the difficulty of changing the diaphragms. They must be very rigidly gripped at the periphery, or so-called "hysteresis" occurs owing to slipping when subjected to pressure, and the lag in return to form when the pressure is removed. For these reasons several designers, Hopkinson and Burstal for example, prefer to use a piston and external spring, but the piston, in its turn, has its own defects, the greatest of which is the need of ample lubrication, with too frequently the corollary that some of the oil is driven in a fine mist into the camera.

The form of spring for the optical, or for the micro-indicator, provides an attractive subject for investigation. When the disk itself is not used as a spring, only two other forms are in use—the cantilever or *encastré* spring, and the bow employed by Hopkinson. There is a possibility of hysteresis in the Hopkinson form, owing to the spring pulling through its attachment when loaded and returning with lag when unloaded. In the cantilever spring this possible defect does not exist. On the other hand, such stiff springs, or bars, as must be used for high pressures must tend to distort the mounting in which they are held. Calibration of the spring in position is therefore essential, and even then some little doubt about accuracy must remain.

The means of connecting and supporting the mirrors is of very great importance. When it is remembered that these mirrors are literally shaken violently some thirty to thirty-five times a second, the need for accuracy in details will be appreciated. On the whole it is better to use one mirror than two, and, if possible, it should be rigidly attached to the spring itself. The fact that the movements of the mirror or mirrors is extremely small, something in the neighbourhood of 5 degrees to 10 degrees, makes it necessary to give attention to minute details if it be desired to measure the indicated horse-power; if the object is only to study the cycle extreme precision is not so essential. In the Watson-Dalby instrument two mirrors are employed, and as each is subject to its own proper errors of mounting the possibility of total error would appear to be greater than in single mirror indicators, like that of Carpentier and Hopkinson. The mirror mounting of the Carpentier instrument is scientifically elegant. The mirror is pressed by springs against three points bearing on its back. The three points are at the angles of a right-angled triangle. The point at the right angle is fixed. One of the others is moved by the diaphragm, and the other by the engine. The incident ray of light should fall on the mirror immediately in front of the fixed point. It is interesting to note that in all these instruments using a reflected ray, if the incident ray does not strike the mirror immediately upon its mechanical axis the scale will be distorted. Another source of trifling error lies in the fact that the screen upon which the image is thrown is flat. Theoretically, it should be a spherical surface struck from the mirror as centre. These little errors are mentioned to show that the optical indicator is subject to defects proper to it, just as mechanical indicators are subject to defects proper to them. It must be the continual effort of scientific inventors to remove those defects.

The optical indicator will remain a costly laboratory instrument until a much less delicate form has been found. Convenient as it is for certain specified purposes to be able to see the "card" on the ground glass screen of the camera, it is questionable whether it would not be better to sacrifice that convenience for the sake of simplicity, accuracy and cheapness and in the hope of producing an instrument that could be used on shipboard. In the Mathot gas-engine indicator—a mechanical indicator—the paper is moved intermittently instead of continuously, and the diagram is drawn by a succession of ordinates. A somewhat similar plan might be adopted for the optical indicator. A single mirror giving a vertical stroke only would be used. A light shutter would be placed in front of the pinhole through which the beam of light was thrown upon the mirror. The shutter would be operated electrically by a commutator which could be set to open it for a fraction of time at any desired portion of the stroke. The position of the dot of light thrown on the screen could be scaled off direct or recorded on a sensitive film which could be moved forward by hand as desired. If the commutator were so devised as to give a score of ordinates at different but fixed points in the stroke, we should have twenty ordinates from which to construct a diagram or derive the mean pressure. As a mere hint to inventors, the author has ventured to place a sketch of this suggested device on one of the wall diagrams.

Mechanically operated optical indicators for high-speed engines suffer from the serious defect that, since, to give trustworthy results, they must be placed practically on the engine cylinder, they are subject to engine vibrations. That is one of the reasons which led to the development of the R.A.E. electrical indicator. But the "balanced" pattern is not the only form possible, and now that exceedingly sensitive galvanometers are available, it is very probable that a pure electrical indicator will some day be found. An interesting form has been tried by Professor Trowbridge, of Princetown University. In it, a small diaphragm is employed. To

the diaphragm a very small coil of fine wire is attached, and into the coil projects one pole of an electro-magnet. When the coil is moved it generates an electric current the E.M.F. of which is proportional to the *velocity* with which the disk moves. The current is taken to a "string" galvanometer of the type designed by the Dutch physicist Einthofen, and by suitable optical means a spot of light is cast upon a moving photographic film. A commutator on the crank-shaft of the engine enables a record to be taken at any desired point of the stroke. Only the pressure chamber with disk and coil are attached to the engine. This part is quite small and can be screwed directly into a hole in the cylinder cover. There are two things to be noticed about this method. First, it is the *velocity* of the disk, and not its *position*, that is measured; the velocity is taken as directly proportional to the pressure. In the second place, it should be noticed that Professor Trowbridge discards the familiar pressure-volume diagram and employs ordinates upon a time basis as shown in the author's suggestion on the wall diagram. There are so many points in favour of this plan that increased attention to it may be safely recommended.

A method of measuring rapid oscillations which is now being developed by Mr. H. A. Thomas at the National Physical Laboratory, and for which an Einthofen galvanometer is also employed, has not so far been used for the indication of engines, but it might be so employed. Mr. Thomas uses a high-frequency oscillating current in a coil. If the coil is brought near a metallic body, a change of conditions which can be measured on a galvanometer occurs.

A third method depends upon the fact that if a pile of hard carbon disks be compressed, their electrical resistance falls inversely as the load increases. Clearly a pressure indicator practically free from inertia might be made with a variable resistance of that kind.

Conclusion

Although Osborne Reynolds probably exaggerated the inaccuracy of indicator cards, and although improvements in the instruments themselves have been effected since he wrote, yet a careful survey of the whole subject leads to the conclusion that no indicators can be relied upon to give results accurate enough to justify the use that is sometimes made of the cards. One may find in the records of engine tests the familiar relationship i.h.p. ÷ b.h.p. taken to the first and even second decimal point, even when the whole number is a large one. Such use of the figures gives an appearance of accuracy which is fictitious, and is to be deprecated. The author ventures to suggest that just as in making standard mechanical parts a tolerance is recognised, so in expressing relationships between factors which have to be obtained by fallible instruments, it would be more honest to state clearly that an error of unknown amount exists. In the case of indicated horse-power he would make that tolerance something like five per cent. for all engines running at or over 300 r.p.m. and for all indicators.

The sources of error in the instruments themselves have already been briefly indicated. But an error of not less importance is that due to the operator. It is generally recognised by all who have investigated the indicator that the pressure of the pencil or scribe upon the paper has a very material effect upon the result. In certain conditions it leads to a damping out of spring vibrations and an improvement of the card, but in other circumstances it may seriously alter the area. When it is remembered that even at as low a speed as 300 r.p.m. a single card must be taken in one-fifth of a second, it will be readily understood that the manipulative skill called for is of a high order. The common practice is to take the mean area of a number of cards—say ten,—but if all are taken by the same operator it is not at all impossible that the same error will persist in all.

The assumption which one may find in text-books that the errors cancel out, that the enlargement of the card caused by pencil pressure, inertia and oscillation is neutralised by the decrease of area that is brought about by drum errors, puts scientific measurement on a low plane, and is not wholly justified by the facts. It is far better, far more honest, to admit that errors do exist, and to refrain from attempting to draw precise deductions from the results.

In concluding this all too brief Paper, the object of which is rather to direct attention to the problems of the engine indicator than to study those problems, the author desires to thank those who have been kind enough to help him with information, and particularly Mr. H. W. Dickinson, of the Science Museum, South Kensington, who prepared, at his request, the interesting table. The author would like to express a hope that members may see their way to add to the admirable collection of indicators preserved at the Science Museum. It is to be regretted that no optical indicators are yet included in it.

WONDERFUL ELECTRIC WELDING

During the war a remarkably ingenious welding equipment was designed for the purpose of fixing brass studs to iron plates. In the construction of a warship it was necessary to fix hundreds upon hundreds of studs to the bulkheads, and the old way of doing it was by cutting holes in the bulkheads and screwing in the studs. In order to save time and labour, the British Admiralty encouraged some of its experts to solve the problem of electric welding under those peculiar conditions, and they eventually perfected a most ingenious machine by which the whole operation of placing the stud, striking the welding arc, and pressing the stud on the plate were performed by clockwork. The results were so satisfactory that the inventors were led to apply the same principle to other kinds of welding. They have now succeeded, by using compressed air, in producing an equipment which will weld studs of almost any kind of metal to plates of almost any kind of metal. For example, brass studs can be welded to very thin tin sheet plate, and a brass stud can be welded to a bronze plate. The main purpose for which this new type of appliance has been perfected is in welding hard tips on to high-speed tools. These tools have to be made with a shank of mild steel, and the tip has to be of special steel in order to give a tough cutting edge. The problem of combining the two has given engineers a great deal of trouble, but henceforward this important operation will be readily carried out to perfection with the apparatus now available.

Mining Accident Statistics

By J. S. P.

We reprint this article from "Industrial Welfare," because it contains ideas which can be put to practical use.

As far as our own experience would show, the analysis of coal mining accidents presents considerably greater difficulty than the analysis of those in other classes of industry. For instance, the percentage of accidents attributable to carelessness in haulage work, is an extremely high one, while that due to explosion is probably a great deal lower.

Statistics show that in 1852, the average loss of life in coal mines, taken over a few years, was about 900 per annum, and during pre-war years, approximately 1,200. It must be borne in mind, however, that in the former period, the output of coal was about 50,000,000 tons, while in 1914 it had increased to 270,000,000 tons. Thus, while the output of coal was 550 per cent. as great, yet the number of deaths had only increased by 150 per cent.

The deaths in 1852 resulted in 24 per cent. from explosions of fire damp, and 76 per cent. from falls of roof and other causes. Taking the average for the years 1905—1914 the figures respectively were 12 per cent. and 88 per cent.

It is fairly safe to assume that the percentage of accidents due to unforeseen and natural causes, is higher in the coal mining industry than others. We believe the correct figures to be approximately 50 per cent. In other industries, a general average being 80 per cent. preventable accidents.

In the experience of the writer, he found that coal mining accidents may be roughly divided into three :

(1) Falls of roof and walls ;
(2) Explosion ;
(3) Haulage and "hand-labour" accidents.

(1) Analysing these causes briefly, falls of roof and walls would appear to be attended by more serious consequences, when the pit is presumably a safe one in this respect, *i.e.*, less precautions are taken in timbering. Further, educational means are necessary to ensure that men having exhausted their supplies of timber, do not continue working without it.

(2) Explosion.—The contributory factors to explosion are the presence of sufficient gas or coal dust, and means of ignition. Educational methods could undoubtedly minimise these factors, gas would be more thoroughly tested, for the pits would be thoroughly stone-washed, and the means of ignition, *i.e.*, the presence of matches, broken flame lamps, seized haulage sheaves, metal parts of tubs trailing on floor, and others, might be almost entirely eliminated.

(3) Haulage Accidents. — These may be largely traced to carelessness or laziness. Riding between tubs, unsuitable means of coupling, jumping on and off moving tubs, excessive speed, and other causes, predominate.

A further series of accidents which are avoidable by educational methods, are those due to neglect of minor injuries, etc.

Although as stated above, we believe the avoidable accidents to be not greater than 50 per cent., it should be added that considerable advantage should accrue from the adoption of educational methods of prevention.

* * *

On the authority of the Mines Inspector for the Northern Division, and as per his annual report, I can state that 41.3 per cent. of *all* the *fatal* accidents in his district during 1921 might be attributed to avoidable causes. This compares with 40 *per cent.* in 1920.

The experience in this district appears to be much higher than in Yorkshire and the North Midlands, where, for 1921, the rate per cent. of *all* the *fatal* (avoidable) accidents due to *falls of ground* was approximately 28 per cent. of the total, according to the inspector's report.

We believe that the actual proportion of what, for the sake of brevity, we call avoidable accidents, has never been estimated for the whole country. If it has we should be very pleased to have the figures. In the short time at our disposal we can find no figures in regard to non-fatal (avoidable) accidents, but probably the percentage is much the same. Personally we believe 33⅓ per cent. (confirmed as an approximate figure by exhaustive tests of both fatal and non-fatal in another district) to be a very conservative figure, but a safe one to work on. This alone involves an annual "avoidable" loss of about 330 lives and 39,000 accidents.

The proportion *of avoidable* "haulage accidents" it will be borne in mind is very high.

The figures we have given are more or less confirmed by the American experience, which is that 40 per cent. of the insurance premium is chargeable to the "human element or moral hazard." We understand that the experience in the South African Union is much the same as in this country.

BRITISH LOCOMOTIVE SUCCESS

One of the many British firms specialising in locomotive production recently gave special attention to the design and construction of locomotives adapted to lines with very heavy gradients and sharp curves. Under such conditions the locomotive has to be made in sections, as it were, so that it can adapt itself to the twists and turns of the track. Several locomotives made by this firm on this principle were recently supplied to South Africa, and they have worked so admirably that a repeat order was recently given to the same firm. This triumph is all the more notable inasmuch as there is practically no demand for such special types of locomotives in Great Britain itself.

ORGANISATION

Conducted by HARTLAND SEYMOUR

THIS SECTION DEALS WITH WORKS MANAGEMENT AND ORGANISATION, THE TRAINING AND WELFARE OF THE WORKERS, AND WITH THE ADVERTISING, SELLING AND MARKETING OF GOODS

Principles of Organisation and Management

By WALLACE ATTWOOD

(Continued from page 617.)

This is a continuation of the important and interesting paper read before the Institution of Production Engineers, the first part of which appeared in our June issue.

IT will be well now to consider the main points that must be borne in mind when building up an efficient organisation. In the old days it was said that a business was but the lengthened shadow of some one man, but with the complexities of present-day business, it will nearly always be necessary to substitute the word "organisation" for "man."

Such a thing as a manufacturer distributing his products nationally was unknown a hundred years ago. In those days business was local in character, and production was small because the market was limited. The enterprise was a personal venture, and where there was steady growth it was perforce simple and slow. The problems of such a man were mainly those of individual effort, influence and common sense. To-day, however, the growth of a business is much more rapid, providing that there is efficient co-ordination and co-operation of capital, management, and employees, and that the organisation is built up upon a similar basis to that laid down in the following ten standards:

(1) *The centralisation of functions that group themselves naturally.*

Many businesses to-day are suffering from the fact that they have grown from the "one-man" business. When such a business was started, the proprietor carried out most of the duties himself. He opened his own shop or commenced working single-handed at his own bench or desk. Then, as his business expanded, he would add an assistant or two, and after a time he would create a manager, and later on a works manager, a chief clerk, a stock-keeper, an accountant, etc.

All the time, however, the tendency would be for him to retain control of much of the detail work, as well as to assume supreme authority and responsibility. So long as he was able to keep a correct grasp of all that went on within his business, all was well, but with continued growth he soon found himself enmeshed in detail, so that there was a tendency for him to lose a true perspective.

There was little or no time for him to get relief from the petty duties of his business in order that he could stand back and secure a correct focus. Consequently his next step was usually to create a number of departments, each with its own head, and he would then keep control of his business through daily contact with his managers.

In the end his organisation would become of the type represented diagrammatically in Fig. 1.

There are many successful businesses organised on these lines, and the fact that they are successful is a real hindrance to their fullest development. Such an employer is apt to argue that he has built up the business and that it has grown steadily by the application of his particular methods. His long acquaintance with the needs of the business makes him resist any suggestion that his method of organisation is wrong. He regards the profits as an effective counter to any argument that may be used. What he does not perceive is that with a more efficient organisation he would have been more successful still. He does not understand, or at least appreciate, the importance of this and the following principles of organisation.

The first duty of an executive is so to arrange his organisation that he deals directly with as few heads of departments as possible. This means that he must divide into groups the functions and duties that are necessary to the execution of his business, reducing the number of groups to the minimum. Thus, if he is a manufacturer, he will group all the functions relative to production under the care of one official whom he may call the works manager. Everything pertaining to administration will come under another head, and the same will apply to finance and sales. He may even go further than this by creating a general manager's department, which will provide the necessary *liaison* between the head of the business and the four main departments already mentioned.

The head of each department will arrange his organisation on the same principle, so that finally an organisation similar to that indicated in Fig. 2 is built up. In this diagram as much detail as possible has been omitted.

Thus this principle consists mainly in splitting up the main purpose or function of an enterprise into many lesser purposes or functions, each of which will be within the capacity of some one individual. It must be remembered that an organisation is limited by the ability and integrity of average people, and by the difficulty of training these people to the point where they can perform the desired task.

(2) *The line of control, authority and responsibility, must operate from executives downwards.*

There is a tendency in many enterprises for the head of a business or of a department to fasten responsibility on to an individual, investing him with the necessary control and authority. Thus the head will frequently

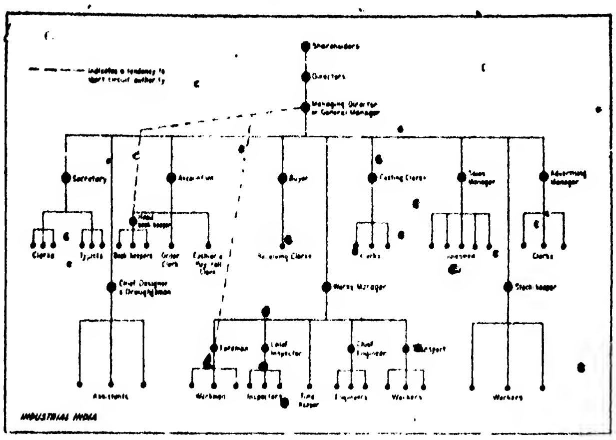


Fig. 1. An example of bad type of organisation

usurp the authority of one of his managers by dealing directly with someone who comes under the control of the manager, and, in so doing, the head may countermand the orders of his manager. Further, he may even arrange for the particular member of the manager's staff to carry responsibility and authority for some small duties which he denies to the manager himself.

Trouble of this nature more frequently arises when the organisation is of the type indicated in Fig. 1. Wherever responsibility is given, it should always be clearly pointed out to the other members of the organisation or department that such a person has the necessary control and authority which alone will enable him to carry his load of responsibility. If this principle is applied step by step in the organisation from the controlling head, through the central manager, the heads of departments, heads of sections, and so on to the rank and file, the following troubles will be avoided:

(*a*) Divided authority. Two men cannot be responsible for the same duty or function, or trouble and friction will very soon arise amongst the members of the staff.

(*b*) Duplication of duties. This is the outcome of the previous fault, and it is no uncommon thing to find identically the same work being carried out in two different departments because responsibility and authority were not properly vested in one man for a specific duty.

(*c*) Bottle-necks. It has previously been stated that duties should be split up so that they come within the capacity of the respective individuals who are to carry them out. It frequently happens, however, that an undue accumulation of tasks occurs at some one or more points in the organisation. Just as in a factory that is producing several parts which have finally to be assembled, where it is recognised that there must be an even flow of production throughout the plant to avoid a hold up at any point, so it is with the whole of a business. If a bottle-neck is created it means that the work of other departments will be held up; so that whilst some members of the organisation are overburdened, others will be forced into semi-idleness.

(*d*) Blind alleys. If each member of the organisation bears some share of responsibility, then by efficient work he should be able gradually to assume greater responsibility, and so avoid a blind-alley job which leads nowhere.

(*e*) Breaches or misfiring. This is where certain duties "fall between two stools." It often occurs that when a certain person has been taken to task about the miscarriage of some particular duty, he says, "I had no idea that I was expected to do this. I thought that was So-and-so's work." The other person is in the same predicament, so that between the two of them the duty fails to be carried out.

(3) *No man responsible to more than one superior for one function.*

The principle that "no man can serve two masters" is particularly true in business. If an employee is directly responsible to two or more superiors for any one duty, he is only human if sooner or later he takes sides. Subterfuge will creep in, and with it passive resistance to the party for whom he does not wish to work. Of course, it is understood that a workman, whilst being responsible to a charge hand, will also be responsible to the foreman to whom the charge hand is responsible. This, however, is not an exception to the point, since the worker is responsible to the foreman through the charge hand. The case would be very different if the same workman were responsible to two charge hands or foremen for the same job.

(4) *Pyramidal support from the lower ranks to the top.*

On referring again to Fig. 2, it may be observed that the chart is in the form of a pyramid, with the greatest number of the staff at the base and the number being reduced as the apex is approached. Thus, whilst authority and responsibility operate vertically downwards, each responsible party should be supported by those immediately under his control. Many heads endeavour to carry the whole burden on their own shoulders; they imagine the diagram in Fig. 2 to be inverted. This is obviously wrong, however. The managing director should encourage his general manager to support him, and the general manager in turn should be sustained in his position by the heads of departments, these being supported in their positions by their respective staffs.

This is conducive to a much stronger and more stable organisation than the other plan.

(5) *Co-operation and co-ordination should be maintained interdepartmentally.*

With the creation of definite departments there is a natural tendency for each department to regard itself as a business within a bigger business, and so to work in watertight compartments. Yet there is very little routine in any business which does not affect more than one department, and therefore for the purpose of carrying out any particular piece of work there must be perfect co-operation between the personnel of the departments concerned.

For instance, an incoming order will affect the administration, sales, production, and finance departments. Possibly twenty people from these four departments will have certain duties to carry out in the execution of the order up to a point where payment has been received from the customer. For the purpose of this order these twenty people can be regarded as co-ordinating their efforts in dealing with the whole of the routine of an incoming order from its inception to completion.

Referring once again to Fig. 2, it may be said that co-ordination between departments works horizontally in either direction.

(6) *Executives and employees must work in complete harmony.*

It is curious how at times one department of a business will consider that it is the mainstay of the enterprise. It imagines that the business begins and ends with itself, that nothing matters except its own point of view. Sometimes in self-interest it will pull in a direction which is diametrically opposed to the good of the business as a whole.

For instance, the sales department may build up a big turnover by obtaining orders in a direction which will bring about a deadlock in one part of the factory, whilst neglecting to obtain sufficient orders for another section of the works. On the other hand, the administration and accounting departments may not work in unison with the sales department. After all, the main consideration is the highest success for the concern as a whole, as the maximum benefit will then accrue to each individual in the business.

A business is rather like a boat. What would one think of a man who elected to pull in the opposite direction to the remainder of the crew working under the guidance of the coxswain? This does not happen with a well-trained crew; they swing and pull together, their sole aim being to bring the boat to its destination by the shortest, quickest, and best route. Similarly, in a business there must be complete harmony so that the desired goal for which the business exists may be reached most efficiently.

(7) *A line of progress which will allow for the growth and initiative of the individual.*

It was Napoleon who said that every soldier carried a field-marshal's baton in his knapsack. In an enterprise every individual should be able to perceive clearly his line of progress if only he will fit himself to take advantage of the opportunities which are bound to arise in a successful business. Employers often decry the lack of initiative among their staff, but in many cases the initiative is deadened because the worker does not see how he can progress within the organisation of which he forms a unit.

Of course, every member of a business cannot be promoted to a higher post, but that is no reason why every individual employee should be able to excuse himself at the expense of the concern for not progressing. Each worker should be shown what chances exist for him, and encouraged to put forward his best. If he does not respond to such stimuli, then he has only himself to blame. On the other hand, if more workers are ripe for promotion than can be accommodated, then at least the business has reaped the greatest possible benefit from such workers.

A business staffed in this way, however, will grow so rapidly that it will be possible to promote a very large percentage. Further, if an employee must leave the organisation for one where there is more room for the exercise of his abilities, the general tone of the industry or type of commercial business in which the firm are engaged is being improved, and ultimate good will be derived even from this.

(8) *The three-positional plan whereby each person is:*

(*a*) Carrying out his own work;
(*b*) Training the man below him; and
(*c*) Understudying the man above him.

This follows naturally from the last point, but it merits special mention since it has been tried with excellent results in many organisations. Arrangements are made whereby as many employees as possible shall not only have an opportunity of learning how to carry out their present duties efficiently, but also of training themselves for the work of their superiors, and of training their own subordinates in the duties they will have to undertake when promoted.

It is realised that this plan cannot be put into execution right down the line, but it is well to apply the principle as far as it is practicable, especially for those occupying the higher positions. It is no uncommon thing for an efficient worker to be passed over for promotion in place of an outsider, because the former did not have an opportunity of learning how to fill the vacant post. It is even more unfair to an efficient man if he is able to fill such a post, but cannot be moved from his present position because there is no one ready to step into his shoes. Such things are very disturbing both to the business and to the man in question.

(9) *Elasticity which will allow for the natural expansion of the business.*

It is not safe to organise according to an opportunist policy for the sake of expediency. Such organisations are in a state of compromise, and are adjusted to the existing circumstances with little thought for the future.

If, in the first place, the organisation is arranged in proper groups, so that all the functions are fulfilled, then each department should be able to expand naturally with the growth of the business. Growth then becomes merely a question of the availability of further capital, accommodation, equipment and personnel, with the possible introduction of further sections and sub-sections of the various departments. Whatever modifications are necessary, however, the organisation should still be able to run on the same approved principles.

(10) *The organisation must be able to give expression to the personality of the business.*

In a small business the personality of the principal will always be in evidence. With the organisation of larger enterprises, however, there is a tendency for more stress to be placed on the inanimate or mechanical side than on the development of a business personality. However large a business may be, and even if the founder is no longer connected with it, it is still possible through the creation and pursuance of the right policy and ideals so to imbue the personnel that, collectively, they give a living personality to the business.

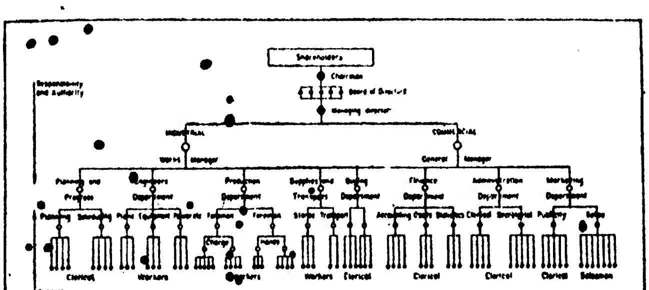


Fig. 2. An example of organisation on modern lines

They carry out their work as one united family, building up a business structure which is a living, virile testimony to their work.

The business develops what one might term a "soul." Without this quality it may exist for a time, but sooner or later certain individuals will begin to regard the concern as something to be exploited, and in times of trade stress the organisation will break down and find itself in liquidation.

Thus there are ten standards by which the efficiency and organisation of a business can be measured. At the same time these standards can be used when efforts are being made to improve the organisation, either of the whole business or merely of a section of it. In this paper organisation is spoken of as the laying down of the foundation upon which the most successful business structure can be built. It should not be confused with system or routine. A system, because it is so called, is not necessarily good, and it is not sound practice to endeavour to correct a fault due to bad organisation by the introduction of some system or routine. This would be like trying to deal with an ever-leaky roof by continually patching it up when the real fault was inherent in the poor construction. Systems are useful and necessary, but not until the organisation is fundamentally sound.

The Scientific Method for Executives

A business to be properly organised must be run on scientific lines and not on "hit or miss" methods. It is important, therefore, that since the organisation is no stronger than the combined efforts of the individuals composing it, each person, and more especially the executives, should carry out their work by scientific methods. Present-day business activities demand exactness and standards by which to measure achievement. Such standards must cover the individual, the products, the methods, and the working conditions. Further, scientific method calls for an inquiry into the ratio between practical achievement and theoretical effort. Thus the executive must work to a programme similar to the following:

(1) Set up standards for every unit in the organisation.

(2) Plan all work intelligently, in general for long periods ahead, and in minute detail for present activities. Then adhere rigidly to the plan.

(3) Prepare all working conditions so that every facility is available for the successful performance of the work in hand.

(4) Compile accurate records with the object of confirming work done and as a guide to future activities.

(5) Limit the amount of detail work for himself, so that he is free to control, analyse and supervise the work of others under him.

(6) Define the limits of the responsibility and authority of those under him.

(7) Standardise the duties of his subordinates and allocate them to those competent to carry them out efficiently.

(8) Organise his work so that his absence for a time will not be felt seriously.

(9) Work always on the law of exception, investigating good work to commend it, and inefficient work to remedy defects.

(10) Build always on a firm foundation, having a positive knowledge of each task.

The Characteristics of a Good Executive

These may also be brought out more clearly by listing them as follows:—

(1) He is always prepared for every emergency. Like a good general he has in reserve plans for retreat, although he means to advance.

(2) "Yes" and "No" are the shortest methods of answering questions, but few executives realise the proper time to use one or the other.

(3) He must have balance or poise so that he is never flurried.

(4) He must inspire confidence in others through his knowledge, experience and qualities of leadership.

(5) He must retain a complete and accurate mental picture of all existing conditions and methods within his department, and the manner in which they affect other departments.

(6) He must have the undivided loyalty of the management and of his men, and must give the same in return.

(7) He must consider team work and co-operation before personal interests.

(8) He must be always ready to step into the position higher up and have someone ready to fill the one he vacates.

(9) He must keep in touch with modern practice, both as regards detail, progress and general trend.

(10) He must instil into subordinates the most useful knowledge of the work.

(11) He must create and maintain the best possible morale in his working force.

(12) He must have wisdom, foresight, and business judgment.

(13) He must carry out the policy of the business and maintain its ideals.

(14) He must stand for reliability and the square deal.

(15) He must be able to induce efficiency in others.

(16) He must exercise control and supervision over his department.

(17) He must be able to analyse results critically and without bias.

(18) He must put new problems before his men for their consideration, advice, and action.

(19) He must see that prescribed practice is carried out.

(20) He must co-ordinate and direct the activities of others, and know how to select and train men who will best aid him in his endeavours, *i.e.*, men who can offset his weaknesses and who can supplement his general information with exact knowledge.

This is a formidable list, but it shows that an executive has a worthy task in front of him, and that it is a position which calls for ability, integrity, and initiative.

The Need for Understanding Men

Men who know how to get the maximum results from machines are common, but the power to encourage the maximum service from subordinates is a much rarer possession. In dealing with men one is confronted with a complex problem. Even when a study of psychology or the laws governing mentality has been made, it is necessary in each individual to deal with his temperament and his personality.

Executives should accordingly seek every opportunity of studying mankind in general, and in particular the men under them. It is one of the main functions of the executive to discover the aptitudes of each individual under his care, and to ensure

(*Continued on page 674.*)

TRANSPORT

Conducted by "M.Inst.T."

THIS SECTION DEALS WITH TRANSIT BY AIR, LAND AND SEA, AND PARTICULARLY WITH THE MANAGEMENT AND CONTROL OF RAILWAYS

Improvement Works on the Indian Railways

A summary of the chapter in the Indian Railway Administration Report for 1921-22, dealing with Rehabilitation and Development, and a few comments upon other matters of railway interest.

In my recent article on "Indian Railways in 1921-22," I referred briefly to the useful innovations in the Administration Report, and indicated my intention of reviewing the information therein contained in a further article. This contribution redeems that promise, and I would add that I am indeed pleased to be able to show a few things to the credit of Indian Railways, more especially in view of the fact that in many of my previous articles on that subject I have felt it necessary to apply the rod of just castigation without mercy.

As an acknowledged railway expert and a fearless critic of railway inefficiency, I have pondered over the lengthy list of improvement works with great interest, and am able to say, without any fear of contradiction, that much real progress is indicated. Doubtless in some respects there is still a suggestion of timidity, but, taken all in all, the hoped-for development on the granting of a large quinquennial sum for railway improvements is well on the way to fruition. It will be of interest briefly to review the major works in hand, and indicate their effect upon railway working generally, as it is essential always to consider prospective developments from the broadest point of view.

Line Widenings and Extensions

Next to the admitted shortage of rolling stock, and, perhaps, more important in certain respects, was the need for additional track facilities on the Indian lines. It is of little advantage to have sufficient rolling stock to meet the maximum demand, and to find that the vehicles are suffering unreasonably long detentions, both *en route* and in yards, owing to insufficient track facilities. Hence it is imperative that these two questions should be considered together.

The information contained in the Administration Report clearly shows that this problem is now being handled on a comprehensive basis. To meet the full and urgent needs of the coal traffic on the East Indian Railway, the main line between Burdwan and Khana Junction is being quadrupled, while between Ondal and Barakar the main line is being trebled and in places quadrupled. In the Jherriah coalfield, also, the line from Dhanbad to Phularitand is being doubled. Coupled with these track facilities arises the necessity for yard accommodation, and those at Ondal, Asansol, Borachuck, Kulti and Sitarampur are receiving attention. These improvements, with others in view, will enable the authorities to work a greatly increased down traffic on an efficient basis, and this, in turn, will tend to accelerate the movement of empty wagons from the northern and western directions. To aid in the free movement of such empty wagons, additional passing points are being provided on the Moghalserai and Allahabad sections, while certain parts of the line between Allahabad and Tundla are to be doubled. The provision of large yards at Gya and Moghalserai, and the doubling of the Grand Chord, are also in hand, and with the other improvements, will provide the necessary facilities for the facile movement of empty wagons to the coalfields.

On the Bengal-Nagpur Railway, many stations are being remodelled, while the line from Anara to Kandra is now being doubled to facilitate the movement of coal traffic from the Jherriah coalfield. When the latter work is completed, it will be possible to deal more expeditiously with coal traffic for Bombay, and more particularly for the Tata iron works at Jamshedpur. From Adra coal for Calcutta will move direct, *via* Khargpur, and for the Tata iron works the traffic will use the two avoiding lines at Anara and Kandra. An additional work of considerable importance is the doubling of 150 miles of main line between Sini and Manharpur, this including the Saranda Tunnel, which is half a mile long.

The Eastern Bengal Railway, on the other hand, while not concerned particularly with coal, has to handle general traffic of high density, and many improvements, mainly of a small character, are in hand for improving the facilities in this regard. It may, however, be noted that in order to avoid the transhipment at present necessitated by the break of gauge, the broad gauge lines are being extended from Santahar, the present terminus, to Parbatipur. Additionally, a system of train control is to be installed at Sealdah, with lines of communication to Ranaghat, Dum Dum cantonment, Majerhat and Chitpur, while on the southern section of the railway several stations are to be remodelled and other improvements effected.

The Bombay Suburban Traffic Problem

The most important consideration in the Bombay area is the provision of a solution for the suburban traffic

problem, and it is to be noted with interest that the Great Indian Peninsula Railway are going ahead with their electrification scheme. At the time of writing the first contract in connection with the electrification has just been placed, and while this has special reference to the Harbour Branch as the first stage, it is anticipated that very shortly the line between Victoria Terminus and Kalyan Junction, a distance of 33½ miles, will be put in hand for conversion to electrical operation. Similarly with the Bombay, Baroda and Central India Railway. For the moment improvement is being effected by the widenings of tracks, the remodelling of stations, and better operating facilities, but these can only be regarded as improvisations. Very soon it will be found essential to electrify the suburban lines, and so relieve the problem of congestion and provide for future development.

Both on the Great Indian Peninsula and the Bombay, Baroda and Central India Railways, many other improvement works are in course of development. In order to enable heavier trains to be run, many of the bridges are being strengthened, while a number of additional passing places, line regradings, station remodellings, etc., are being given preference in the schemes now in hand. Projects which may specially be noted are the proposed provision of a new marshalling yard near Igatpuri, a new yard on the Itarsi Jubbulpore Branch, and a tranship yard at Ghorpuri, close to Poona.

The strengthening of track and bridges is the most important item of expenditure to be faced by the South Indian and the Madras and Southern Mahratta Railways. A considerable amount of work has already been done, but there still remains a lot to be accomplished ere it will be possible to run the heavier trains required to meet the traffic needs. Many station improvements and shop extensions are also projected on both these lines, while special attention is to be paid to the requirements of the third-class passengers and the suburban traffic problem of Madras.

The other railways to which reference is specially made in the Administration Report are the Burma Railway, the Oudh and Rohilkhand Railway, the North Western and the Assam-Bengal, and while, speaking generally, it may be said that a systematic programme of improvement works is contemplated, the items are not individually impressive. Special improvements are the entire remodelling of Lucknow traffic yard on the Oudh and Rohilkhand, the provision of a new locomotive shop near Karachi, and extensions to the Moghalpura shops on the North Western line, together with station remodellings and line widenings in many places.

Line Opened During 1921-22

It is worthy of notice that during the last financial year 125.14 miles of new lines were opened for public traffic, about one-third of which represented mileage built by Indian States and about half by private companies. Incidentally, it may be added that the relaying of the Sutlej Valley line, which was torn up during the war to provide material for military needs, has been commenced. The Administration Report emphasises that with the heavy programme of work in connection with open lines to which India is now committed, further extension of railway communication will have to take second place. The quinquennial programme authorised by the Legislative Assembly, upon the recommendations of the Railway Finance Committee, provided that the sum allotted should be devoted primarily to the rehabilitation of existing lines, and it is this that must receive special attention for the present.

Increase in Rolling Stock Equipment

In the comprehensive programme to which reference has been made, rolling stock naturally receives preferential treatment, as the exceeding deficiency in this connection was strongly emphasised—as it needed to be—in the Acworth Report. Of the Rs. 150 Crores to be spent during the five years 1922-23 to 1926-27, a goodly percentage is earmarked for additional rolling stock, and when the orders have been fulfilled, a good deal of the leeway should have been made good.

At the end of the last financial year the Indian Railways possessed 9,743 locomotives, 25,240 coaching vehicles, and 207,516 goods vehicles, and if the five years' programme, as drawn up, is carried out, this equipment should be reinforced by 942 locomotives, 6,699 coaching vehicles, and 32,300 goods vehicles. As, moreover, the Report points out, these numbers were based on a very high level of prices current when the programme was framed, "it now seems possible that they will be very substantially improved upon."

In a country such as India, the necessity of progressive improvement in the development of railway communications must be obvious to all. That the railways have been more or less "starved" is a fact as true as it is deplorable—and yet during the twenty years preceding the war, India increased her railway mileage by 15,756 miles. Continued progress on this scale would undoubtedly have benefited the country, but, as the Report says, times are changed. In pre-war days a broad gauge line could be constructed and equipped for about a lakh a mile, whereas the average cost to-day is Rs. 1½ lakhs. At the same time it is imperative that the railways of India should be extended and developed to a higher pitch of efficiency. This can only be achieved by enabling them to be adequate to carry all the traffic offering for conveyance, and, if anything, to be in advance of the requirements. The five years' programme, therefore, while specially dealing with existing lines, is a great step forward, and though the railways of India have a great leeway to make up, there can be no doubt that under the more enlightened conditions now obtaining, and under the new organisation that is in course of establishment, improved results will be secured in the near future.

Principles of Management

(*Continued from page 672*)

that the worker has a certain versatility in the duties allotted to him, which will bring out his aptitudes. At any rate, these natural abilities must be discovered and developed. Economic loss due to wasted manpower is not fair to the man, the business, or the country, and cannot be tolerated. In a sense a man has a right to look to his superiors to help him to discover himself.

Each worker must be happy. It is necessary to understand his weaknesses and to be prepared for the trouble they may cause. The whole essence of the art of management lies in proper understanding of, and dealing with, men, in encouraging good points and remedying faults.

(*To be continued.*)

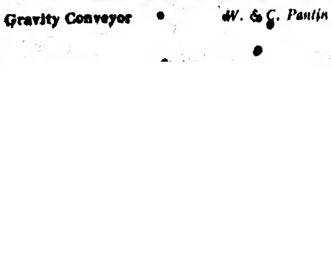
Internal Transport Methods

In this article we deal with the handling of goods and raw materials under the modern conditions prevailing in our factories, workshops, and warehouses.

THE handling of goods and raw material under modern conditions has resulted in the development of many different methods of transport within the factory and warehouse. Most of these methods are merely a further development of older methods, but they have been evolved after much thought and experience to meet the many different conditions obtaining under our present-day conditions.

The results from such developments have given industry a means of handling mechanically almost any class of goods or material, but care is necessary in selecting the most suitable method in any particular case, and in most cases it will be found that several different methods will be finally adopted to complete the circuit of the material from the input end of a factory, through the various manufacturing processes, and finally to the output end for external transport.

The principal economic advantages of internal transport are a saving of time and labour. Time saving by such methods is generally fairly obvious, but it is not generally realised that a very considerable saving in labour costs can often be effected by a well-considered method of internal mechanical transport, and the capital



Gravity Conveyor W. & C. Pantin

sunk in such plant made to pay a handsome return, in addition to relieving labour for more skilled work.

We propose in this article to deal only with some of the more recent developments in this field, such as runways, special trucks, gravity tracks, stacking machines, and conveyors. It must be remembered, however, that our old friend, the crane in its many different forms, still plays an important part in connection with the more recent developments.

Considering first the modern runway, this consists of an arrangement of overhead rails, upon which is carried a suitable lifting gear. Such gear is mounted on a small carriage fitted with ball or roller bearing wheels for ease of handling. The rails used may take the form of standard rolled steel joists, or special forms which have been evolved by different makers.

In cases where this system is applicable, it is generally found that the cost of installation is a relatively small matter by comparison with the resulting saving. The overhead rails can be arranged to pick up and deposit goods exactly where they are required, and, in addition, the lifting gear enables stacking in the building or loading on to truck or lorry, with a minimum of handling, and in a manner which has obvious advantages over ground transport.

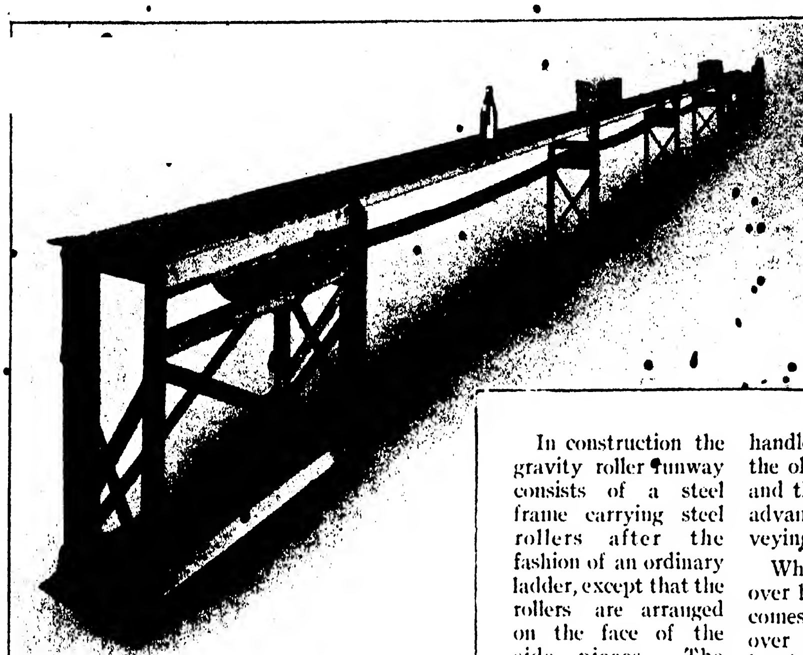
A development of this system is the overhead self-propelled runway, operated by means of electric motors. This arrangement really becomes a single track crane, and may carry the operator on the carriage, or can be operated from the ground by means of cords. The great advantage of this system over the hand-power runway is the great increase in speed of operation, which is many times greater when motive power is adopted.

Gravity Conveyor W. & C. Pantin

Where it is not possible, or not economical, to instal overhead gear, the many forms of ground trucks call for special consideration, and in many cases, of course, these trucks also work in conjunction with the overhead gear.

The electric storage battery truck is the type in most general use, and has made very considerable progress during recent years. It is not only simple in construction and in operation, but is also practically fool-proof. These trucks are built in capacities from ½ to 4 tons, and have a speed up to 7 and 8 miles per hour. A storage battery supplies the source of power, and a series motor drives the back axle of the truck by means of chain or suitable gearing.

A special feature of these modern power trucks is the provision made for automatic control. For example, should the driver leave the truck without due regard for its safety, there is no fear of any danger, because the brakes are automatically applied immediately the driver leaves the platform. Another point is the design of the controller. Should the driver release his hold on the controller handle, it automatically returns to the "off" position.



Endless Belt Conveyor

Electric trucks are usually fitted with rubber-tyred wheels, but they can also be supplied with flanged wheels, to run on rails. A further development is the fitting of a small jib crane to the platform of the truck, capable of lifting loads up to about 2 tons. In such an arrangement the truck retains its platform capacity for transporting goods, and has the additional advantage of the lifting capacity of the crane, which is always at the spot where it is required. The crane is provided with a separate motor, but the same accumulators of course supply both truck and crane motors.

The method of transporting goods by means of gravity roller runways is making rapid progress, and has certain special claims for consideration. This system is merely a development of the old-fashioned chute, but providing rollers for the goods to travel on, and arranging for change of direction to negotiate corners. The outstanding advantages of this system are that it is always ready for use, and costs nothing to operate beyond depreciation, and it is also portable.

In construction the gravity roller runway consists of a steel frame carrying steel rollers after the fashion of an ordinary ladder, except that the rollers are arranged on the face of the side pieces. The rollers themselves are formed from steel tubes for lightness, and mounted on axles running in ball or roller bearings in order to reduce friction to a minimum.

The most important feature of any gravity system is to determine the correct gradient necessary for the particular goods to be transported. This can be done by actual trial, and light goods will be found to require a steeper gradient than heavier goods.

It should be noted that with a gravity roller system the pitch of the rollers is a variable factor. If long lengths of timber are to be carried, there would be no reason for placing the rollers close together, but if very small packages have to travel, then the rollers will have to be quite close up to each other. The determining of this factor, therefore, is an important one, as regards cost, of installation.

The roller runway may also be used as spiral conveyor for lowering goods from one floor to another. In this manner goods are handled without damage as against the old-fashioned spiral slide chutes, and the roller spiral has the further advantage that it is capable of conveying quite fragile material.

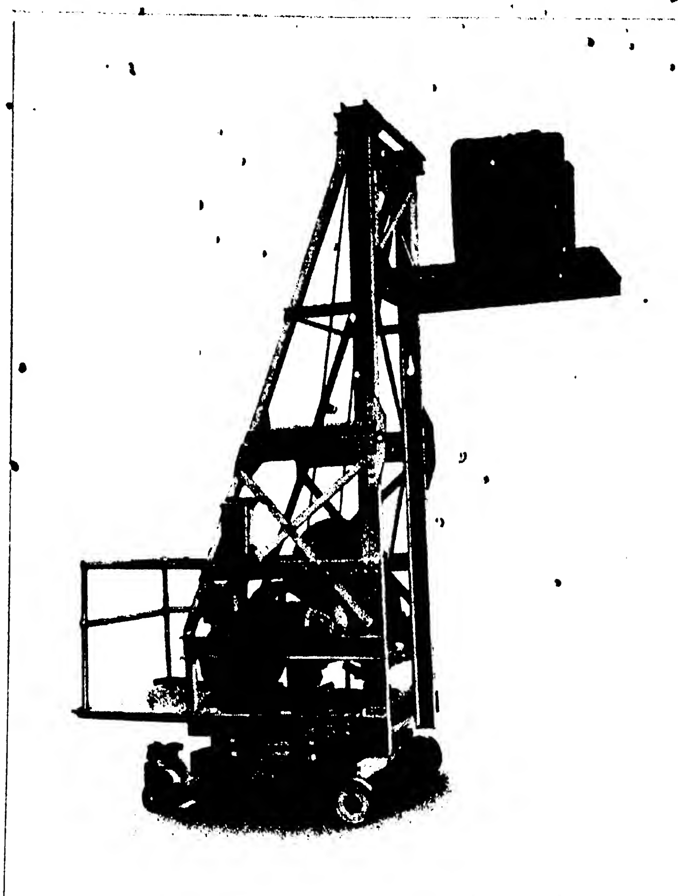
When the gravity system is used over long distances, it frequently becomes necessary to start the incline over again after a certain distance has been travelled. This will readily be understood when it is remembered that the gravity runway is gradually coming down to the ground, so that it is only a matter of a certain distance when the effect of gravity is lost. In order to continue, therefore, it is necessary to provide some form of lifting gear to lift the goods up on to a new line of runway. This is generally arranged by means of an endless conveyer working at an angle between the bottom of the first runway and the top of the second runway, so that the goods from number one

Portable Belt Elevator

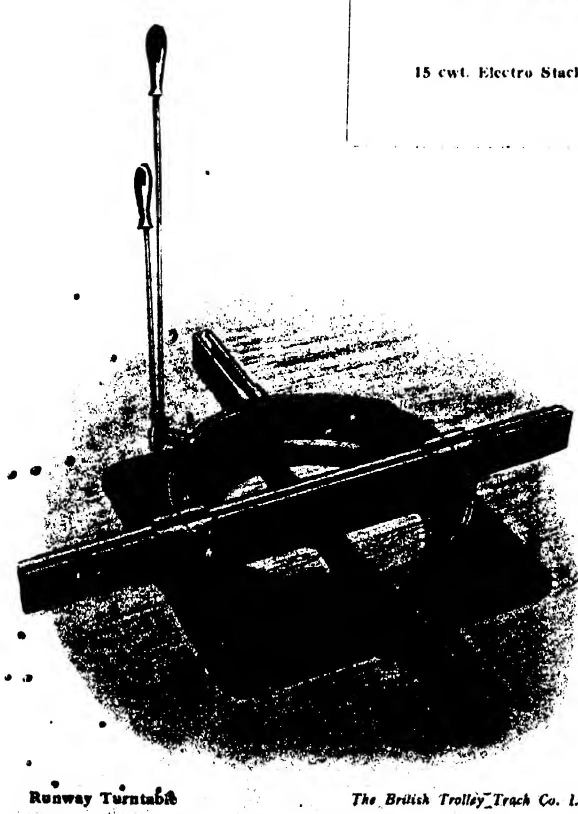
run on to the endless conveyer, and are carried up and slide off on to the top of number two gravity runway. Such endless conveyer may be operated by means of a small electric motor, and, of course, may be insulated at a number of points in the runway circuit, according to the distance to be covered.

Considering, now, the actual stacking of goods in a warehouse or store, it will readily be recognised that it is quite useless having a highly efficient transport system unless the means are provided both for loading and unloading at the respective ends of the system. The unloading and stacking of many classes of goods calls for the labour of a number of men at the points of unload and stacking when purely human labour is adopted. This is not only laborious, but it is slow, and, as already stated, is tending to reduce the efficiency of the transport system, as naturally the speed of the whole system will be dependent upon its slowest unit.

The modern stacking machine has therefore been evolved to pile up the packages and cases arriving in the warehouse in a more or less continuous stream from the transporting system. A common form of such stacking machine is a suitable size platform mounted on the front of a telescopic steel framework which is capable of vertical movement. The whole apparatus is mounted on ball bearing wheels, so as to be easily movable from point to point according to where the stacking is required. The goods to be stacked are placed on the platform, when they are immediately raised to the required height by means of an electric motor, and deposited on the top of the stack by the simple operation of pulling a lever.



15 cwt. Electro Stacker — *The Wellman-Smith Owen Engineering Corporation Ltd.*



Runway Turntable — *The British Trolley Track Co. Ltd.*

The electric supply for the motor is generally taken from plugs which are installed at suitable points in the building, and the smaller machines are operated by hand.

Where large quantities of raw material have to be transported, the

Overhead Runway — The British Trolley Track Co. Ltd.

pulleys below the lower portion of the belt in order to carry the slack.

The direction of travel with a band conveyor is naturally in a straight line, but it is a simple matter to change the direction in which the goods are travelling by transferring them to another band which is placed in the new direction it is required to travel. The goods are transferred from one band to the other by means of a stationary plough placed at an angle across the first band, and are automatically pushed off and drop on to the second band.

The bands used to carry the goods may be flat, or troughed. In the former case the band simply runs over flat pulleys, but for a troughed conveyor it is necessary to provide guide pulleys or rollers, which are set at an angle and arranged along each side the whole length of the belt conveyor.

The material of the carrying band is generally a special fabric composition, and therefore is suitable for conveying all manner of goods which are of a dry nature, and at normal temperature. It will perhaps be useful to put on record here that steel bands are now available for such conveying purposes, and although the writer has no data regarding experience with such bands, it would appear that they would have a much longer life than those of fabric composition.

"There is an increasing need for effective leadership through the ranks of industry, an increasing need for capacity to handle men."

continuous band conveyor has been very largely adopted. For the transport of grain, for example, this method has become almost universal for carrying the grain in a horizontal plane. This method is also largely used for the transport of ore, coal, etc., and also when small packages in large quantities have to be handled.

There are a great many different arrangements for band conveyors, but fundamentally they all operate on the same general principle. An endless belt is mounted on two pulleys—one at each end of the system,—power is applied at one pulley to operate the belt, and a tension gear is fitted at the other end of the system. It is necessary, of course, to provide intermediate idle pulleys to support the upper portion of the belt which is carrying the load, and further idle

Electric Tractor — The Lansing Equipment Co., London

The Modernisation of Passenger Railway Stations

By F. BUSHROD, O.B.E., and J. F. S. TYLER

This concludes the paper read before the Institute of Transport, the first part of which appeared in our June issue

(*Continued from page* 627.)

In considering the lay-out or design of any station, due consideration must, of necessity, be given to the question of the signalling scheme to be employed, with particular regard to the relation and effect of such a lay-out upon the signalling arrangements that will have to be installed to serve the dual role of affording the necessary protection, and of giving the maximum amount of freedom to train movement. Although, at first sight, it might be thought that the signalling of a station may be subordinated to that of lay-out, the two—signalling and lay-out should, as a general principle, be looked upon as inseparable, and endeavour be made, wherever practicable, to ensure that the standard or established principle affecting the one be not sacrificed to the peculiarities of the other. As an illustration, mention may be made of the cases that are sometimes met with of a stop signal having to be placed about mid-way along a platform merely to protect a trailing connection in the platform line, although a similar signal is also found necessary at the extreme end of the platform to control the starting of trains and to ensure the full length of the platform being utilised for the work of the train. Again, how often does one see a multiplicity of signals, or signals placed in undesirable positions, on account of curvature and various obstructions to the view of enginemen? Further, cases are also frequently come across where the lay-out of stations has necessitated signal boxes being placed in awkward positions, with the result that costly schemes of track circuiting are considered necessary to give the needed improvement from the signalmen's point of view. These cases may be taken as examples shewing how the questions of lay-out and the signalling arrangements are closely allied. Having, then, determined the lay-out of any station and its effect upon the signalling arrangements, consideration is next given to what system of signals shall be installed, and what power shall be employed to work the points. Taking the first of these two items, the signals, if the station be a "through" station dealing with moderate traffics, no great difficulty should arise in placing the requisite signals to meet the working requirements, such as are provided for in the Ministry of Transport's Requirements for Working Railways, but at large stations, whether they be of the "through" or "terminal" type, problems, that frequently tax the ingenuity of the traffic, as well as the signalling officer, have to be confronted. It is here that such modern appliances as track circuits, and power working for points lend themselves to the solution of difficulties. These appliances, although usually entailing heavy first cost, have an important bearing upon the cost of working a signal box, and it is this phase of the question, together with the area covered by the lay-out of points and connections and saving of time in manipulation, not forgetting also the less strain imposed upon signalmen, that make it desirable for a power plant to be employed in working large stations, rather than a mechanical plant necessitating the employment of additional signalmen, with its other attendant disadvantages. The use of track circuit at such a station is also not only of inestimable value to a signalman, indicating as it does the occupation of any section of line within the working area of the signal box, but serves a useful purpose in affording protection at fouling points, thus eliminating electrical or mechanical fouling bars. Track circuits also form a very important function in the working of large terminal stations where, by a division of the track circuits in platform roads, in conjunction with an appropriate arrangement of outdoor signals, a train can be admitted to the platform while a train or vehicles are already occupying one section of the platform road. Such an arrangement of track circuits is installed at Waterloo Station on the whole of the platform roads, and by the provision of calling-on signals situated underneath the incoming home signals, a train can be admitted to the platform by the lowering of the home signal if the platform road for its full length is clear, or by the lowering of the calling-on signal only if one portion of the platform road is occupied.

Signalling Arrangements

Another important aspect of the signalling arrangements at stations is the necessity for their simplification. Especially is this so at large terminal stations where a running line approaching the station serves a number of bays or platform roads; in such a case, in order to avoid a multiplicity of signals to serve all the roads, the modern practice is to instal route (or platform road) indicators working in conjunction with the home signal. In this respect, the arrangements at Waterloo Station may again be quoted as typifying simplicity in signalling; at this station, four up—or incoming—lines serve twenty-one platform roads, but four home signals only are provided to control trains entering the station, with a route indicator (containing a series of numbers corresponding to the number of the platform roads served by the incoming line) provided for each home signal. This arrangement, as will readily be seen, is a distinct advantage, from an engineman's point of view, in areas where a dense train service is experienced.

Mention may also be made of the relation of automatic signalling to

the working of large stations where the sections on either side lend themselves to the installation of such a plant. In busy areas, it is usual to find a number of intermediate section signal boxes, where the signalmen are only concerned with the passing of trains and not with any crossing or point movements, but, at present-day costs, the maintenance of such section boxes, particularly if situated on sections of lines where the traffic necessitates their being open continuously, forms a heavy item in traffic expenditure. These section boxes can be avoided by the laying down of a system of automatic signals, controlled by track circuited sections of line, so spaced apart as to accommodate between signals the longest train run over the section affected, and to give the required capacity for ensuring rapidity of train movement.

The employment of automatic signalling may also be the means of avoiding expenditure on the widening of lines. Before the advent of this system of signalling in Great Britain, the usual method of making provision for increased train services was to widen the railway, four tracks usually taking the place of two. As may be readily appreciated, the outlay on widening works of this nature entails a heavy expenditure apart from the cost, which in itself often forms an almost prohibitive item, of securing the necessary property. Difficulties of this nature can frequently be surmounted, by installing on the section of railway affected, a series of automatic block signals of a capacity to meet the desired increase in train services.

Another feature worthy of mention, as denoting the development of modern signalling practice, is that applying to the acceptance of trains at junctions. At these places, it is now usual for outer home signals to be erected both on the main and branch lines at the junction to enable two trains from the respective directions to be accepted simultaneously, under which arrangement all signals can be lowered for the main line train to run at speed through the junction, while the branch train is running as far as the branch line outer home signal, or *vice versa*. By this means, the delay to a train at the section to the rear, either by " block," or for the purpose of carrying out the provisions of the " section clear but junction blocked " warning arrangement, is eliminated, and especial benefit to train movement is derived in cases where one section to the rear of the junction is appreciably longer than the other.

The foregoing remarks are intended to illustrate briefly the possibilities of employing labour-saving and up-to-date appliances at places where the lay-out of lines and stations lends itself to their installation; the extent of their employment will, of course, vary according to the nature and density of the traffic to be handled, the availability and situation of site for the laying down of the proposed plant, and anticipated revenue or return on capital expenditure; but, whether the nature of the new work to be undertaken be large or small, it will generally be found prudent not to dissociate signalling from lay-out. Finally, the underlying features governing consideration of this question may briefly be summarised thus :—

1. Traffic requirements—passenger and goods—both present and prospective.
2. Extent and design of lay-out.
3. Installation of signalling arrangements to give maximum amount of freedom to train movement.
4. Simplification of signalling on standard principles.
5. Minimum of capital expenditure and maintenance in working.

Effect of Station Design on Construction of Time Table

The design of a station has a very important bearing on the construction of the time table, particularly in regard to the following three features :—

(1) A junction where branch line trains have to be dealt with.

(2) Wayside stations on lines passing through sparsely populated districts, with large towns at either end between which a heavy traffic passes.

(3) A large terminus where many fouling movements must of necessity be made.

With respect to (1), at a junction station, much time may be saved and the difficulties of constructing a time table minimised, if separate platform roads are provided for the reception and despatch of branch trains. If the branch train has to run to the same road as the trunk train, it must, of necessity, be timed to arrive much earlier than if separate roads are provided, as the train would have to discharge its passengers and other traffic prior to being shunted, and until this latter is done the trunk train cannot be accepted. On the other hand, with an independent platform road, the branch train would clear the line for the trunk train immediately upon arrival, and the margin of time between the two trains would be governed only by the length of the block section.

Lay-out of Wayside Stations

As to the second point, viz. :—the lay-out of wayside stations, as a general rule all that is necessary is one platform for up trains and another for down trains, but, in the conditions mentioned above, the capacity of the line may be considerably restricted, and the difficulties of time table construction enhanced, unless facilities are provided at one or more of the wayside stations for switching a stopping train off the running line to enable a non-stop train to overtake and pass it *en route*. This can be attained by providing a runnning loop at a station, or even extending from one station to another. Much time may be economised thereby, and the capacity of a line considerably improved.

With regard to the third point, the design of terminus has a considerable influence on the construction of a time table, and a failure to provide certain facilities may reduce to a very great extent the number of trains that can be dealt with. At a terminus, means of disposing of the engine hauling the train in are necessary, and these should be so designed as to enable the engine to run to the locomotive depot (if this is necessary before making a return trip) or to another platform road for its next duty with a minimum of shunt movements, and, as far as possible, without fouling other platform roads.

Concluding Remarks

In conclusion, this paper is not intended to represent anything in the nature of an exhaustive treatise on the subject, but rather an endeavour to direct the line of thought to a few central ideas worthy of consideration in connection with the modernising of existing or designing new stations, but it is hoped that the observations herein contained may not be regarded as unprofitable to the students who I have the privilege of addressing to-night.

SCIENCE

Conducted by A. H. HAVER, M.I.N.A. & K. S. DICKINSON, F.C.S.

THIS SECTION DEALS WITH THE APPLICATION OF SCIENCE TO INDUSTRY AND PARTICULARLY DEALS WITH APPLIED CHEMISTRY

Combustion and the Production of Fire

(*Continued from page 628.*)

ALTHOUGH the most familiar examples of combustion are those which take place in air, the term combustion must not be restricted only to such cases. Combustion, in its widest meaning, is a process of chemical action in which so much heat is generated that the burning substance becomes incandescent and emits light; and such a process may occur even when no air or oxygen is present. Thus, for example, the gas hydrogen will burn not only in air, with production of the substance water, but will also burn in the gas chlorine with formation of the compound known as hydrogen chloride or hydrochloric acid gas. And, similarly, other cases of combustion are known which do not depend on the presence of oxygen, and are not processes of oxidation.

Even when the combustion is due to the combination of the combustible material with oxygen, to a process of oxidation as we have called it, the oxygen need not be present in the gaseous form, but may be yielded up by some compound containing it. Various well-known substances, such as chlorate of potash and saltpetre (potassium nitrate), can act as suppliers of oxygen in this way, and the use of such substances for promoting combustion has long been known. Touchpaper, for example, the slowly burning paper which is so familiar in connection with fireworks, is prepared by soaking paper in a solution of saltpetre, and allowing it to dry. The saltpetre is in this way deposited in the fibres of the paper, and renders the latter more readily combustible. Such paper does not require the presence of gaseous oxygen for its combustion, but will burn in an atmosphere of nitrogen or other inert gas. In the case of gunpowder, also, which we shall discuss at a later point, saltpetre is similarly made use of as a reservoir of oxygen.

In recent years, the process of combustion by means of combined oxygen has been turned to a very good account for the purpose of obtaining economically, and with ease, the metals chromium, manganese, and titanium, which could formerly be obtained only with considerable difficulty. The metal aluminium, we have seen, has a great affinity for oxygen, and it combines with great vigour not only with gaseous oxygen, but also with the oxygen contained in compounds. If, then, we mix the oxide of chromium with aluminium powder, and strongly heat the mass at one point by means of a special ignition mixture, the aluminium combines with the oxygen of the chromium oxide, and so much heat is thereby generated that the combustion rapidly spreads throughout the whole mass. Oxide of aluminium is formed, and the metallic chromium, which is set free, is fused, and collects at the bottom of the vessel. In this way large quantities of chromium are now produced for use, more especially in the manufacture of a "stainless steel," which does not tarnish in contact with food or acids; and also of a very hard steel known as chrome steel. By the introduction of this process, known as the Goldschmidt process, chromium, which twenty years ago cost as much as £25 a pound, can now be obtained for 12/6 a pound.

A modification of the above process has become familiar in recent years through its application to the welding of tramway rails, and to the repair, *in situ*, of broken castings, shafting, etc., by the so-called thermit process. For this process, oxide of iron is employed instead of oxide of chromium, and the molten iron which is produced, and which has been raised to a temperature of about 5,400 deg. F., by the vigour of the reaction, is run into a mould formed round the ends of the rails or fractured metal. The rails are thus raised to such a high temperature that they can be readily welded by pressure, or the fracture is filled with fresh iron and a solid joint effected.

The very high temperature produced by the combustion has also led to the use of thermit mixture in incendiary bombs designed to be dropped from airships, the bombs being furnished with a special mechanism by means of which the thermit mixture can be ignited automatically.

In order to bring about the various cases of combustion which we have been discussing, it is necessary, as we have seen, to raise the temperature to a certain point, the ignition point. Nowadays this causes no difficulty; and it may be regarded as not the least of the services which chemistry has rendered to man, that it has put it within his power to obtain fire at will, with a minimum both of trouble and expense. From the primitive method of rubbing two dried sticks together, to the use of the flint and steel; and from the latter to the modern safety match, is indeed an advance the importance of which for

our modern civilisation it would be difficult to estimate, and impossible to over-estimate.

One of the characteristics of chemical action, as we have seen it exemplified in the process of combustion, is the production of heat, but it was not till early in the nineteenth century that practical suggestions were made for the employment of such a means of producing fire. One of the earliest of these suggestions which had a certain measure of success was made by a Frenchman named Chancel, who tipped strips of wood with a mixture of potassium chlorate and sugar, bound together by means of gum. When this composition was dipped into concentrated sulphuric acid (oil of vitriol), the sugar took fire and burned at the expense of the oxygen contained in the potassium chlorate; and this combustion was then communicated to the wood splint. These matches were sold as late as the middle of last century. About 1827, John Walker, an Englishman, patented a match the tip of which consisted of a mixture of potassium chlorate and sulphide of antimony, and this mixture could be ignited by being drawn between folds of glass paper. These matches, known as lucifers, were the first friction matches used.

But there is a substance the use of which for matches is at once suggested both by its name and by its properties, the readily inflammable substance phosphorus, which was discovered as long ago as 1669, and is prepared at the present day from calcium phosphate. From the readiness with which this substance ignites, it was only natural that attempts should be made to utilise it as a convenient fire-producer. Such attempts were at last successful, and phosphorus-tipped matches, known as Congreves, were in almost universal use until a comparatively recent time. The tips of these matches consisted, essentially, of a mixture of phosphorus, and some substance rich in oxygen, such as potassium chlorate, or red lead (oxide of lead), bound together with gum or glue, and coloured with various pigments. We can all recollect these matches, which had such a fascination for us in our younger days through the glow of phosphorescent light which they emitted when slightly warmed by rubbing on the hand. As fire-producers these matches were a great advance on those which had gone before. But for every advance a certain price has to be paid, and for the phosphorus match mankind has found the price too heavy. The accidental fires due to the readily inflammability of the phosphorus, and the general danger of its unrestricted use; the number of deaths, accidental or intentional, produced by phosphorus poisoning; and the terrible disease known as "phossy jaw," or necrosis of the jaw-bone, which attacked the workers in the match factories, led to a ban being placed on what had been hailed as a boon; and the use of ordinary white or yellow phosphorus has, in most civilised countries, been forbidden by law.

But the element phosphorus occurs not only in the readily inflammable and poisonous white variety, but also in a totally distinct form, that of a dark-red powder which is much less readily inflammable, and is non-poisonous. It is produced by heating ordinary phosphorus in closed vessels to a temperature of about 480 deg. F. Attempts were therefore made to utilise this form of phosphorus, and the difficulties which were at first encountered, were ultimately overcome by a German chemist about the middle of last century, and his invention, first taken up in Sweden, led to the introduction of the so-called Swedish or safety match. In these matches the red phosphorus is not incorporated in the match head, but is used in the composition with which the rubbing surface is coated. The match tip consists of a mixture of sulphide of antimony, and an oxidising substance such as potassium chlorate, red lead, or potassium bichromate; and sulphur and charcoal are sometimes added. This mixture will not take fire when rubbed on a rough surface, but only when rubbed on the specially prepared surface coated with a paste of red phosphorus mixed, sometimes, with sulphide of antimony and powdered glass. Moreover, in order to diminish the risk of accidental fire through the glowing wood of a used match, safety matches are soaked in a solution of alum, sodium phosphate, ammonium phosphate, or some other salt. The charred wood of the match is thereby strengthened, and the match ceases to glow almost immediately after being blown out.

When the use of white phosphorus was forbidden, the attention of chemists was directed to the discovery of other materials which might be used instead, and a non-poisonous match was produced which possessed the advantage of the old phosphorus match, of striking on any rough surface. In the case of this "strike anywhere" match, the tipping composition consists of a mixture of sulphide of phosphorus and potassium chlorate, or other oxidising material, bound together with glue, and powdered glass is also sometimes added to increase the friction, and so facilitate the inflammation of the match head.

To render the wood of the match more readily inflammable, and so allow of the combustion passing on from the tip of the wood, the latter is impregnated with paraffin wax, although, sometimes, as in the case of some Continental matches, sulphur is employed instead.

In the case of Vesuvians, the match head consists of a mixture of powdered charcoal and nitre, to which some scenting material, such as gum benzoin or sandal wood, is added. This head is then tipped with a striking mixture such as has already been described.

The making of matches, once a "dangerous occupation," has now passed from the handworker to the machine, which not only cuts the blocks of wood into splints of proper size and shape, but tips them with the inflammable mixture and packs them into boxes, which it also makes and labels. A single machine can thus turn out over 5,000,000 matches in a day. Only by such means could the almost incredible number of matches be produced which are turned out annually by the match factories of the world. The firm of Bryant & May, the largest British manufacturers, can alone produce, in the course of a year, as many as 90,000,000,000 matches, not to mention wax vestas and tapers, and it has been estimated that the annual consumption of matches in Great Britain amounts to about nine matches per head of population per day.

Although the ordinary match forms by far the most usual means of obtaining fire and light, one must not fail to mention the recently introduced briquets, or "cigar lighters." When an alloy of iron and the metal cerium is rubbed against a piece of steel, small particles of the alloy are rubbed off and take fire in the air. If the sparks so produced are allowed to come in contact with a piece of tinder or with the vapour of petrol, or similar volatile liquid, the latter takes fire, and we thus obtain a flame. In this apparatus we have, in a refined form, the old flint and steel of our fathers.

Ceria, or oxide of cerium, is now produced in large quantity as a by-

product of the manufacture of incandescent gas mantles, and is derived mainly from monazite sand, valuable deposits of which are found in Brazil and also in Travancore, India. It was while investigating how the accumulations of ceria might be utilised, that Auer von Welsbach discovered, early in the present century, the peculiar property of the iron-cerium alloy which led to the above application.

The Protection of Metals from Heat Oxidisation

BY F. S. LOVICK JOHNSON, A.M.I.MECH.E.

The process described in the following article is controlled in England by the Scarab Oil Burning Co. Ltd., London, who have recently completed the erection of a new calorising plant

THE present high cost of labour and materials for replacements and maintenance renders particularly interesting any method whereby these charges may be lessened. In this connection the problem of the oxidisation of metal parts when subjected to the action of intense heat is of great importance; generally speaking, there is hardly an industrial plant in the country which is not experiencing some oxidisation problem from high temperature, and the loss accruing from labour, material, time and lay-up of equipment is enormous.

The destructive action of heat is, of course, no new problem, but one which has confronted those engaged in the mechanical arts ever since the beginning of the iron and steel age, and for many years past scientific research and inventive ingenuity have exerted themselves to provide a remedy. Although from time to time various processes have been introduced for protecting metals against oxidisation and the corrosion due to acids and the atmosphere, there is only one process in existence which is primarily intended to give protection against oxidisation at high temperatures. This recently developed process is known as calorising, which is the only successful and economical process for rendering metals highly resistant to the ravages of high temperature.

The Calorising Process

The process of calorising was discovered by T. Van Aller, in 1911, and developed by the General Electric Company of Schenectady, U.S.A., and although it has only been applied commercially to any extent during the past three years, it has proved its value in America, and is now attracting considerable attention in England.

Broadly, the process of calorising consists in the formation of a surface alloy of aluminium on ferrous and non-ferrous metals, and is achieved by placing the articles to be treated in an air-tight retort, partly filled with the calorising mixture (which consists of finely divided metallic aluminium suspended in aluminium oxide), and subjecting it to a high temperature for several hours. During the process, a continuous current of hydrogen is passed through the retort to ensure an inert atmosphere. Before being placed in the retort the articles are required to be thoroughly cleaned and to have a surface free from grease, scale and other foreign matter, this being effected either by sand-blasting or pickling. The treatment, conducted at high temperature, so thoroughly infuses aluminium into the exposed portions of the metal being treated as to form a homogeneous alloy for a certain depth. This depth ranges from a few thousandths of an inch to the permeation of the entire mass and is governed by varying the duration of the treatment and the composition of the mixture. It is thus apparent that the essential difference between calorising and processes hitherto used commercially is that the protective surface is not imposed as a coating or skin upon the metal to be treated, but, on the contrary, enters into intimate association with it, forming a solid solution alloy. It must not be confused with any coating process like galvanising, sherardising, coslettising, or oxide coatings. It is, moreover, distinct from the numerous homogeneous alloys, some of which, containing nickel or chromium, are highly resistant to oxidisation at high temperatures. Calorising differs from such alloys in that it consists of using a relatively inexpensive metal, such as iron or steel, in itself readily oxidisable, but covered with a continuous protective alloy coating which becomes a homogeneous part of the metal treated, and which is effected at a comparatively low cost.

The calorised coating consists of a comparatively thin alloy layer, which is very rich in aluminium, but on being subjected to high temperature under working conditions this alloy layer penetrates or diffuses further into the metal, forming a larger amount of homogeneous ferro-aluminium alloy, and an outer coating of aluminium oxide, which is the protective surface. It is thus apparent that, should the outer surface become injured, the protective surface will renew itself by the oxidisation of the alloy exposed.

Limits of Temperature

The limiting temperature at which calorised articles will withstand oxidisation is governed by the nature of the alloy formed and the service to

which it is subjected. Generally speaking this limit varies from 900 deg. C. to 1,000 deg. C. Above 1,000 deg. C. the diffusion of aluminium is so rapid that the alloy quickly becomes too weak in aluminium to form a satisfactory protective oxide, with the result that the underlying metal will commence to scale.

Regarding the physical properties of calorised metal it has been found that the process anneals the material, giving results which are favourably comparable with those obtained by a soft annealed finish. From the various investigations carried out it has been proved that any change in the physical characteristics of the average application does not require serious consideration ; the properties of strength, electrical and thermal conductivity varying with the cross section affected by diffusion and generally speaking the thermal and electrical conductivity are somewhat lowered by the process. Samples submitted to crushing, flanging, expanding and pulling tests have demonstrated that calorised material is capable of withstanding all ordinary handling without destruction of the alloy, while microscopic examination has revealed the quality of homogeneity.

It should, however, be understood from the nature of the hard and somewhat brittle protective coating that calorised metal cannot be bent or hammered cold, but at a bright red heat it may be bent without affecting its resistance to oxidisation. The principal machining operations should therefore be carried out on the articles before being calorised, although calorised boiler tubes can be satisfactorily expanded cold without detriment if they are made of seamless steel. The dimensions and weight of the metal treated are only very slightly increased by calorising, the increase in dimensions being not more than a few thousandths of an inch. Calorisation increases the life of metal articles from ten to thirty times, according to the material and conditions of temperature to which they are subjected, the protection afforded depending considerably upon the proportion of the cross section affected by the alloying and the percentage of the aluminium content.

Application to Various Metals

Various metals may be calorised—cast iron, wrought iron, malleable iron, steel, nickel, nickel steel, copper and brass, and in all instances where metals suffer from the ravages of heat oxidisation, the wasting effect of some forms of corrosion or the deleterious effect of certain gases, calorising can be used with advantage. The results obtained with certain metals are better than with others; for instance, greater protection will be afforded to mild steel articles, particularly those which have been mechanically treated by processes such as rolling, spinning, etc., than ordinary castings. Good results have been obtained from castings of pure ingot cast iron carefully made and of small parts, but low grade ferrous castings invariably contain slag, sand-inclusion, blow-holes and other imperfections which break up the continuity of the surface and prevent homogeneity in the alloyed surface. The amount of free carbon present also appears to exert a deterrent influence on the depth of penetration of the protective medium. Again, the characteristic "growth" of cast iron on repeated heating and cooling tends to crack up the surface layer of oxide with the result that in a short time the aluminium content will become too weak to form an efficient oxide coating and breakdown will occur. Wrought iron is likewise a very variable material in the matter of quality, and with poor grades of wrought iron containing mixtures of genuine wrought iron and steel scrap, large percentages of slag and phosphorus, it is impossible to guarantee good uniform results. Excellent results, however, have been obtained with good grades of steel castings, good quality wrought iron, mild steel, etc.

Acid-Resisting Qualities

Calorising is primarily a protection against burning or scaling at high temperatures, but there are numerous instances where it is most effectively employed to meet conditions other than the primary one for which it was intended. Calorised non-ferrous metals such as copper, brass and nickel, are excellent non-corrosive elements resistant to atmospheric conditions and certain acidous liquids. Calorised ferrous metals are likewise strongly resistant to the effect of carbolic acid, hot tar, and pitch, and also to the wasting effect of sulphur dioxide and carbon monoxide gases as present in furnace gases.

In Fig. 2 the results of a sulphur dioxide test are illustrated. Two pieces of extra heavy wrought iron pipe, one calorised, the other uncalorised, were run side-by-side in a furnace at 820 deg. C. (1,500 deg. F.) in an atmosphere of sulphur dioxide for a period of four hours. At the end of this time the ordinary untreated pipe was badly burned, as shown, while the calorised pipe appeared in all respects in as good condition as before the test.

A further sample illustrating the comparison is shown in Fig. 3. This annealing box was cut in halves, one half was calorised and the other untreated. Both halves were then

FIG. 3

welded together, and the box as a whole was subjected to a temperature of 820 deg. C. for a period of thirty hours, with the result as shown.

Industrial Applications

In the various industries there are many applications where the marked superiority of calorised metal for unusual heat conditions has consistently yielded good results, of which the following may be cited :—Pyrometer protection tubes ; carbonising and annealing boxes ; metal furnace linings ; baffles, etc. ; lead pots ; oil cracking pipes ; superheater tubes ; locomotive firebox stay nuts ; marine boiler furnace stay nuts ; air preheating tubes ; fire bars ; parts of continuous " operation " furnaces, such as link chains, saddles, buckets, muffle rolls, etc. ; parts of tunnel kilns ; thermostat fire ends ; producer gas filter chambers ; pottery racks ; molten sulphur containers ; soldering irons ; carbolic acid lines ; copper controller contacts ; copper condenser tubes ; valves for [illegible] gases ; valves and piston heads for Diesel engines ; parts of glass manufacturing equipment, such as gatherers, mantle rods, etc. ; soot blower equipment ; retorts ; hot bulbs for oil engines.

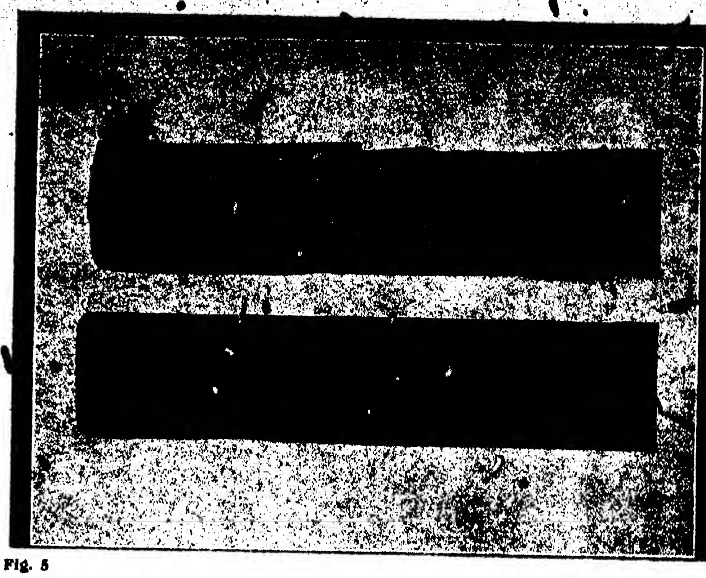


Fig. 5

There are, however, many possible applications which have not been treated, and which will suggest themselves to the engineer, metallurgist, and works manager, in connection with the equipment used in their individual process of manufacture.

With reference to the cost of the process, this is not excessive, having regard to the saving effected, both in the labour and material involved in renewals. It is claimed that the cost of calorising a given article is in many instances actually less than the cost of a similar untreated replacement, a fact which makes it an attractive proposition from an industrial point of view.

What Others are Doing

A TRAILER CRANE

In many factories and warehouses great use can be made of a light portable crane which can be readily transported from one point to another for the purpose of lifting and stacking goods. Various forms of runabout cranes on trucks driven by electricity, steam, or oil, have been devised, but they all suffer from the drawback that the equipment cannot be conveniently used otherwise than, as a crane ; therefore it comes rather expensive in cases where lifting work is only occasional. To meet these cases a British firm has devised a light crane capable of lifting up to 15 cwt., which can be hitched on to an ordinary electric industrial truck as required and hauled to the scene of action. This crane is mounted on two rubber-tyred wheels, and has a third support in the form of a pivot, so that it can be rapidly fitted on to the truck or taken off again when the lifting work is finished. The crane is driven by current from the batteries of the truck itself. The jib of the crane can be lowered so that the whole thing can be run through an ordinary doorway, and it is capable of raising a load from ten feet below ground level to thirteen feet above ground level. Experience has proved that a workman quickly gains the knack of manipulating this crane with the greatest ease. At times, when no lifting has to be done, the crane is simply dismounted and the truck used in the ordinary way for carrying goods backwards and forwards.

THE LATEST TANK

Most of us will remember the tremendous sensation that was caused when the deadly military engine, known as the " tank," was first introduced under service conditions. As is natural with a novel appliance of this kind, the first productions were rather crude ; but their success was so manifest that expert attention has been constantly devoted to their improvement. So much success has attended this effort that the British Government has given an order for twenty tanks of the latest type. The new machines will attain a speed of twenty-five miles per hour without over strain, as against eight miles per hour with the old tanks ; and whereas the first tanks were done for after about 150 miles, the new ones will have an endurance of about 1,000 miles. Each tank has a length of 35 feet, and is provided with an armoured turret. Special attention has been given to the design, in order to enable the tank to be used not only in the regular way for attack, but as a tractor for hauling heavy guns into position.

A MODEL-MAKER'S LATHE

The making of models of all sorts of mechanical contrivances, boats, and so on, is a hobby which is pursued in all parts of the world with remarkable enthusiasm. Quite an industry has grown up, especially in Great Britain in the production of special tools for the use of model-makers. Many of these enthusiasts are persons of moderate means, and are unable to afford the costly lathes drills, and other appliances which they would like for very accurate work. The lathe is the instrument most used, and in order to meet the demand for a thoroughly accurate and yet cheap appliance a British firm which specialises in small precision tools has turned out a lathe at the astonishingly small cost of 50/-, by which boring, drilling, milling, sawing, slot-drilling, grinding and so on, can be carried out with a very high degree of accuracy. This lathe will turn articles up to 4 in. in diameter, and 12 in. in length. The makers will supply this handy little appliance with treadle motion, electric motor, or any other accessories, according to the requirements of the purchaser. It is of entirely new design, and each part is made by mass production on the accurate lines adopted in first-class British machine tool manufacture.

AIRCRAFT IN MAIL SERVICE

Aeroplanes are already being used to a considerable extent for certain mail services and for general commercial purposes, but there is a touch of originality about the proposal made by an eminent British naval architect for the regular use of aeroplanes in connection with large vessels on long voyages. He proposes that a passenger vessel should be built on much the same lines as the aeroplane carried which figured so prominently in the British Navy towards the end of the war. The uppermost deck of the vessel provides a flat expanse upon which the aeroplane can alight, and from which it may take off. With a vessel of this type it will be possible for aeroplanes to convey mails and passengers to the ship long after it has left port. The design has been worked out in great detail, and shows a 24,000-ton vessel with a speed of twenty-one knots on ordinary running. Water-tube boilers with oil burning are suggested, and electricity is to be used for all ventilating, pumping, cooking, and other services. The whole scheme is worked out on commercial lines; and one of the chief advantages suggested is that on a voyage, say from Great Britain to Australia, the vessel could run to Port Said without a stop—passengers and mails being taken off by aeroplane at the various ports on the run.

A REMARKABLE PUMP

Information was published lately regarding a new type of British pump designed to deal with fluids in which a large proportion of solid matter was carried. In that type the pump had a kind of scissor action which broke up the solid material and enabled it to be carried forward. The inventiveness of the British engineer has, however, produced still another solution to this problem, which bulks so largely in the work of the sewage engineer. The new pump is a centrifugal pump in which the solid material is, as it were, by-passed. By a curious arrangement of partitions, the solid material is separated from the water, which is sucked through in the ordinary way, while the partitions push forward the solid matter by a different track. This pump is adapted not only to handling sewage, but in pumping water from weed-fouled rivers. In tests made with this pump, attempts were made to jam the machine with lumps of coal, pieces of wood, and balls of cotton waste, but these were all passed through without damage.

STEEL CLAD WOOD

The material known as three-ply wood, or plywood, has now come into very extensive use for many purposes where thin and strong partitions are required. It is made by fixing together three thin layers of wood in a manner which affords great strength and freedom from warping. The latest development of this ingenious invention has been produced by a British firm. It consists of chemically cementing to the ordinary multiple wood, on one or both of its faces, a sheet of steel coated either with lead or zinc. This arrangement gives the wood a protective and fire-proof surface, and it also opens up the possibility of many interesting applications. Weight for weight the new material is claimed to be at least eighty times as stiff as mild steel. The purposes for which it is at present intended are for shelves, doors, etc., in houses and shops, for body work, dash boards, roofs, and so on in vehicles, for the sides and seats of railway cars and tramcars, and for wheel discs, pulleys, lifting cages, and so on in general engineering. The material is made in standard sheets, and it can be readily cut by means of a circular or band saw. Wire nails may be driven through it, and if fixing by screw nails is required, holes can be formed by one operation by means of a punch.

SOMETHING NEW IN BUFFERS

In the making of railway buffers the usual process is to weld the flat portion on to the shank. This method is quite satisfactory from the users' point of view, but it occupies a good deal of time, and therefore adds to the cost of the article. A Sheffield firm which has been engaged on buffer making and other railway appliances for many years has designed a plant which completes the manufacture of railway buffers without any welding. All the work is done by large hydraulic presses, and the new plant is capable of an output of no fewer than one thousand complete buffers per week. So successful has the new plant proved, that it enabled the Company to obtain an order for 13,000 complete buffers in the face of Continental competition. The works engaged on this production are working at high pressure night and day, and extensions are now on foot.

AMITY OF NATIONS

Between nations, as between individuals, what is most to be dreaded is the silence which engenders misunderstandings. It is in the exchange of ideas of different points of view that the true path towards reciprocal understandings is ever to be found. Patience and tolerance between nations is as productive of happy results as patience and tolerance between individuals.—René Viviani, Former Primeer of France.